No. 1006 No. 403 No. 1007 No. 1036 No. 376 No. 369 No. 390

First Cross Dorset Down Ewes. Sired by pure bred Dorset ram (Fig. 7) and out of Down grade ewes (Fig. 6). The average weight of nine shearling ewes Nov. 23rd, 1893, was 153 lbs. The average weight of the seven two-year old ewes, shown in photograph, Nov. 15th, 1894, was 185.5 lbs. Nine shearlings sheared an average of 7.1 lbs. in April, 1893, and eight ewes sheared an average of 10.8 lbs. unwashed wool April, 1894.

ELEVENTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN

For the year ending June 30, 1894.

MADISON, WISCONSIN:
DEMOCRAT PRINTING COMPANY, STATE PRINTER.
1895.

☞The Bulletins and Annual Reports of this Station are sent free to all residents of the State upon request.

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General Offices and Departments of Agricultural Chemistry, Agricultural Physics, Animal Husbandry, Bacteriology, Farmers' Institutes, and Library, in Agricultural Hall, near University Hall, on Upper Campus.

Dairy Building and Horticultural Building, west end of Observatory Hill, adjacent to Horticultural Grounds and Experiment Farm.

Telephone to Station Office, Dairy Building and Farm Office.

LETTER OF TRANSMITTAL.

EAU CLAIRE, WIS., October 1, 1894.

To His Excellency, GEO. W. PECK,

Governor of Wisconsin:

I have the honor to transmit to you herewith, in accordance with law, the Eleventh Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

WM. P. BARTLETT,

President of the Board of Regents,

University of Wisconsin.

REPORT OF THE DIRECTOR.

This report covers the government fiscal year ending June 30, 1894, for its financial statement, and the work of the several investigators so far as complete down to the time of going to press December 1, 1894. By this promptness we hope to be able to present to our constituents the results of our work in time for their winter reading during the earlier months of 1895.

Irrigation investigations.—During the past season we have begun a series of investigations in irrigation for garden and farm crops believing that this effort would meet with approval. Though Wisconsin lies wholly within the humid region, the precipitation is such that crops not infrequently suffer from drought; the summer 1894 was a marked example in this particular.

Our equipment for irrigtaion work consists of a 10 H. P. traction steam boiler and engine, a large centrifugal and a small rotary pump, a cement reservoir, 40 feet in diameter, considerable piping, etc.; to these we hope to add materially during the coming year especially in the way of piping, so that we may be able to show the value of additional water on field and garden crops. The results of the investigations by Professors King and Goff will be read with interest by our people, and are especialy commended to those raising crops where there are possible large incomes from an acre, notably vegetables and small fruits.

Marsh drainage.—During the past fall a most interesting experiment has been inaugurated on the university farm. About 40 acres of our farm lies with its surface so near to the water level of Fourth Lake that drainage as usually practiced is out of the question. Ten acres of this land, a small portion of which is actually below lake

level and all of which has remained incapable of cultivation for the reason above stated, has been rescued from uselessness and put in the way of possible high agricultural value through diking and draining. A dike has been built along the inlet to the lake to prevent overflow from that side; inside this dike a ditch between three and four feet deep has been excavated which empties into a reservior 40 x 60 feet in area and four feet deep. Tile drains are laid 33 feet apart under the ten acres; these empty into the open ditch which in turn carries the water to the reservoir.

A 14 foot Eclipse windmill working an 8 x 10 inch cylinder pump with direct stroke lifts the water out of the reservoir over the dike and into the lake. This is practically the Holland systen for reclaiming low-lying and submerged lands, and if the project proves a success we shall be able to add materially to our present arable lands on the station farm and afford an example for others to follow.

Tuberculosis in the Station dairy herd.—Last winter Dr. Russell of the Station, and Dr. W. G. Clark, instructor in veterinary science, conducted a test of our dairy herd for tubercular consumption, by the acid of the Koch tuberculin lymph. It was found that nearly all individuals of the herd were affected with the disease and one after another the animals were slaughtered during the investigation until twenty-eight were destroyed, leaving but two cows which were pronounced free from the disease. We are now without a dairy herd and the stable in which our cows were kept is we believe so thoroughly infected that it is not advisable to place valuable animals therein. For this reason we are without a herd of cows at the Station ,and shall await legislative assistance in the way of a new barn before any steps are taken in this direction.

The Station force.—During the past year there has been no changes in our Station force, a matter for congratulation when we read of the many changes going on in some of our sister Stations. Mr. E. H. Farrington has come to us from the University of Illinois, with the title of Asso-

ciate Professor of Dairy Husbandry, his work being in the dairy school as head instructor and investigator. By thus increasing our force of dairy workers we hope to be able to do still better work in the future than in the past, helping on an industry, the importance of which is even not yet fully realized by the citizens of our state. No state in the Union combines equal advantages for butter and cheese-making with ours, and only a short-sighted policy will hold back our university from being a leader in the enormous development possible in this direction.

In justice to two of our workers a word of explanation is deemed necessary. When the Babcock milk test was given to the world we hardly realized what would follow. A large part of Dr. Babcock's time for the last three years has been taken up with correspondence relating to this test, and with work connected with the dairy test of the World's Columbian Exposition. Mr. Woll has given much of his time to editing and general supervision of our report and bulletins, and to caring for our agricultural library. For these reasons we have not been able to present the amount of chemical work which would seem due from this part of our Station force.

The mailing list.—Our old mailing list which numbered more than 8,000 names was the accumulation of years and needed thorough revision. Notices were sent with our Tenth Annual Report that all persons receiving the same should send in an application if they wished their names to remain on our list. We again renew our offer. All citizens of our state wishing our Reports and Bulletins are requested to send in their names with county and post-office.

Publications available for distribution.—Most of our earlier publications are now out of print. We have on hand and will supply to residents of this state only, until exhausted, any of the following:

Eighth Annual Report for the year 1891.
Bulletin No. 14, Artificial Fertilizers and Land Plaster.
Bulletin No. 16, A New Method for Determining Fat in Milk (Short's Test), July '88.
Bulletin No. 18, The Constitution of Milk.
Bulletin No. 19, Notes on Ensilage, April, '89.
Bulletin No. 21, Comparative Value of Warm and Cold Water for Milch Cows in Winter, October, '89.

Bulletin No. 22, Report on Oats, Barley and Potatoes for 1889, January, '90.

Bulletin No. 23, Prevention of Apple Scab, April, '90.

Bulletin No. 25, Feeding Bone Meal and Hard Wood Ashes to Hogs Living on Corn, October, '90.

Bulletin No. 26, Sugar Beet Culture in Wisconsin, January, '91.

Bulletin No. 27, The Feeding Value of Whey, April, '91.

Bulletin No. 28, The Construction of Silos, July '91.

Bulletin No. 29, Creaming Experiments, Octobar, '91.

Bulletin No 30, Sugar Beet Experiments in Wisconsin for 1891, January '92.

Bulletin No. 32, Feeding Grain to Lambs, July, '92.

Bulletin No. 33, Rations for Dairy Cows.

Bulletin No. 34, Preventive Treatment for Apple Scab, Downy Mildew and Brown Rot of the Grape, Potatoe Blight and the Smut of Wheat and Oats, January, '93.

Bulletin No. 35, Insects and Diseases Injurious to Cranberries, April, '93.

Bulletin No. 37, The Russian Thistle, October, '93.

Bulletin No. 38, One Hundred American Rations for Dairy Cows, January, '94.

Bulletin No. 39, Noxious Weeds, April, '94.

Bulletin No. 40, Tuberculosis and the Tuberculin Test, July, '94.

Bulletin No. 41, Grain Feeding Lambs for Market, August, '94.

Bulletin No. 42, Destructive Effects of Winds on Sandy Soils and Light Sandy Loams, with Methods for Protection, October, '94.

EXPERIMENTS IN SWINE FEEDING.

W. A. HENRY.

I.—Food Required During Growth by Full-Blood Poland China and Berkshire Pigs.

The following trial was conducted for the purpose of ascertaining the food of growth with full-blood pigs. The breed, age, etc., of the animals used was as follows:

Breed.	Animal.	When farrowed.	Name and Address of Breeder.
Poland China..	Boar..	May 21, 1890	C. M. Brigham, Hebron, Ill.
Poland China..	Sow No. 1	Apr. 11, 1890	Theo. Louis, Louisville, Wis.
Poland China..	Sow No. 2	Mch. 28, 1890	Theo. Louis, Louisville, Wis.
Poland China..	Sow No. 3	Apr. 4, 1890	Geo. Wylie, Leeds, Wis.
Poland China..	Sow No. 4	Apr. 4, 1890	Geo. Wylie, Leeds, Wis.
Berkshire......	Boar	Feb. 25, 1890	A. J. Lovejoy & Son, Roscoe, Ill.
Berkshire.....	Sow No. 1	Apr. 7, 1890	A. A. Arnold, Galesville, Wis.
Berkshire......	Sow No. 2	Mch. 11, 1890	A. A. Arnold, Galesville, Wis.
Berkshire.....	Sow No. 3	....	W. H. Jacobs, Madison, Wis.
Berkshire.. ...	Sow No. 4	....	W. H. Jacobs, Madison, Wis.

These animals were choice representatives of the breed, selected for us by the breeders themselves; they may therefore be considered representative according to the judgment of friends of the breed. The animals reached the Station in August, and beginning with the 18th of that month, for 224 days thereafter each was fed separately, all feed being carefully weighed and recorded.

The sows run together on a good short blue-grass pasture until winter, when they were confined in a roomy pen, being separated only at time of feeding. The grain fed during the whole trial consisted of half wheat shorts and half corn meal. The milk was separator skim milk containing very little fat, and the whey was from our dairy school cheese room. During Periods II and III two sows

from each breed received half a pound of cotton seed meal daily while two sows and the boar received an equal weight of oil meal. At the beginning o Period III these two feeds were reversed so as to give a fair average for the whole time.

Our aim in this experiment was to so feed as to keep each animal in the best possible growing condition not getting too fat. Weight considered, it was found that the daily food consumption of the animals on this trial was practically the same in amount one with another, and this uniformity continued throughout the whole trial. No animals were ever sick or off feed, all of which goes to show that they were vigorous animals well selected by the breeders and that the feeding was carefully conducted. The data of this trial occupy nineteen closely filled pages of figures and the tables here given are the summaries of several thousands separate weighings of food and animals.

The following table summarizes the feed consumed during the three periods covering 224 days in all, the weights of the several animals at the beginning of the trial, and the gains for each period. The sows were all bred during the month of January.

Table showing food eaten and gains made by Poland China and Berkshire pigs.

	Length of period—days.	FEED EATEN.				ORIGINAL WEIGHT AND GAINS.				
							Sows.			
		Grain.	Cottonseed meal and oil meal.	Skimmilk.	Whey.	Boar.	1	2	3	4
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
A.—Poland China.						70	103	121	105	102
Period I........	154	2,747	.....	6,122	2,600	159	165	156	159	163
Period II..	35	616	*82	400	1,640	33	36	45	38	37
Period III.............	35	613	†88	.....	2,640	31	31	44	40	31
Total.................	224	3,976	170	6,522	6,880	***223***	***232***	***245***	***237***	***231***
B.--Berkshire.						172	99	85	86	65
Period I.	154	2,617	......	6,136	2,644	153	164	149	184	163
Period II...............	35	616	‡92	400	1,640	30	37	38	34	34
Period III..............	35	583	§88	......	2,530	25	35	33	38	50
Total.........	224	3,816	180	6,536	6,814	***208***	***236***	***220***	***256***	***247***

*55 lbs. oil meal. † 35 lbs. oil meal. ‡ 37 lbs. oil meal. § 53 lbs. oil meal.

The above figures, though greatly condensed and carefully arranged, are stili not in shape to be easily studied; to make the results of our work plainer let us further condense and rearrange. To this end we note the total gains of the two lots for each of the periods. This was as follows:

	Poland China (1 boar, 4 sows).	Berkshire, (1 boar, 4 sows).
Period I, 154 days, gain made	802 lbs.	813 lbs.
Period II, 35 days, gain made	189 lbs.	173 lbs.
Period III, 35 days, gain made	177 lbs.	181 lbs.
Total, 224 days	1,168 lbs.	1,167 lbs.

We note that five full-blood Poland Chinas, one boar and four sows, gained 1168 lbs. in 224 days, while five Berkshires gained 1167 lbs. in the same time, or within one pound of what the Poland Chinas gained, an agreement quite surprising.

Let us next note the food required for 100 lbs. of gain during all the periods, which is shown in the following table:

Table showing the food required for 100 *lbs. gain, live weight, with full-blood Poland China and Berkshire pigs, during growth.*

	Poland China (1 boar, 4 sows).	Berkshire (1 boar, 4 sows).
Grain	310 lbs.	327 lbs.
Cottonseed meal and oil meal	15 lbs.	15 lbs.
Skim milk	558 lbs.	560 lbs.
Whey	589 lbs.	584 lbs.

The striking similarity of the two columns of figures may be made more apparent if we can substitute a grain equivalent for the skim milk and whey fed. Fjord of Denmark, as the result of a large number of feeding experi-

ments with swine,* concludes that one pound of barley or rye meal equals 12 lbs. of whey or 6 lbs. of skim milk. If we substitute these meal values of the whey and skim milk we have:

Table showing food required for 100 *lbs. of gain.*

Poland Chinas.

Corn meal and shorts as above reported	340 lbs.	
Cottonseed meal and oil meal	15 lbs.	
Meal equivalent of 558 lbs. skim milk	93 lbs.	
Meal equivalent for 589 lbs. whey	49 lbs.	
Total grain and equivalent for 100 lbs. gain		497 lbs.

Berkshires.

Corn meal and shorts as above reported	327 lbs.	
Cottonseed meal and oil meal	15 lbs.	
Meal equivalent of 560 lbs. skim milk	93 lbs.	
Meal equivalent of 584 lbs. whey	49 lbs.	
Total grain and equivalent for 100 lbs. gain		484 lbs.

The above table shows that our group of Poland Chinas consumed 13 lbs. or 2.7 per cent. more feed while making 100 lbs. of gain than did the Berkshires. This difference is so small that it is believed to come entirely within the limits of error for this class of work. By this it is meant that were we to conduct a similar trial where both lots of pigs were Poland Chinas or both lots Berkshires, there might be as large or even a larger difference in the weight of food required for a given gain with the two lots as is here shown.

Our trial shows that Berkshire and Poland China pigs used for breeding purposes after reaching a weight of about one hundred pounds can be carried up to a weight of over three hundred pounds on feeds which favor and promote bone and muscle growth, with a requirement of about 500 lbs. of meal or meal equivalent for each hundred pounds of increase in live weight.

* Fodringsforsoeg med Svin, 1887.

II.--Cotton seed meal and linseed meal as a partial grain food for pigs.

As stated in the previous experiment during the last two periods cotton seed meal and oil meal were fed to the full blood hogs there under trial. To give more prominence to this portion of the work the following statements are made: Beginning January 19th, one-half pound of cotton seed meal was fed to a portion of the hogs and an equal amount of oil meal to the others. After thirty-five days the feeds were reversed. The following table summarizes the results:

Table showing the food consumed and gain during two periods of 35 days each with hogs receiving one-half pound of oil meal or cotton seed meal daily.

	Avg. Wgt.	Gain.	Food Eaten.			
			Grain Feed	Cotton Seed Meal.	Milk.	Whey
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Period II (35 days), 3 Berkshire..........	274	105	370	56	240	984
Period II (35 days), 2 Poland China.......	265	75	247	37	160	656
Period III (35 days), 2 Berkshire..........	283	68	245	35	....	1,056
Period III (35 days), 3 Poland China.....	296	106	368	53	....	1,584
Average and totals........	261	374	1230	181	400	4,280
				Oil Meal.		
Period II (35 days), 2 Berkshire..	249	68	247	37	160	656
Period II (35 days), 3 Poland China.....	258	114	369	55	240	984
Period III (35 days), 3 Berkshires	307	93	338	53	.....	1,474
Period III (35 days), 2 Poland China......	302	71	245	35	....	1,056
Average and totals....	280	346	1199	180	400	4,170

From the above we deduce the following:

Food for 100 lbs. of gain with pigs getting onehalf pound each daily of oil-meal or cotton seed meal.

	Hogs fed Cotton seed meal.	Hogs fed oil meal.
	lbs.	lbs.
Grain	329	347
Cotton seed meal	48	....
Oil meal	....	52
Milk	107	116
Whey	1,144	1,176

Giving to whey and milk their grain equivalent as used in the previous trial, we find that for 100 lbs. of gain, live weight, it required 492 lbs. of meal or its equivalent, with the pigs getting cotton seed meal, and 516 lbs. of meal or its equivalent with the pigs getting oil meal. Our pigs receiving oil meal therefore ate 24 lbs. or 5 per cent. more of feed than did those getting cotton seed meal.

Carefully conducted experiments at the Texas Station* show that whenever cotton seed meal is fed in any considerable quantity to hogs, although they may thrive at first, serious losses through death are sure to follow, if the practice is continued. In one experiment where twenty pigs were used, ten died within ten weeks after beginning the feeding of cotton seed or cotton seed meal, and in a second that with fifteen pigs seven died from the same cause.

No deleterious effects were noticed with our pigs, but it should be remembered that the experiment lasted only seven weeks and that the quantity of cotton meal fed was very small. Unfavorable results were not noted in the Texas investigations until several weeks after the beginning of the trial. It is probable that cotton seed meal can be fed to pigs successfully as in our case where the quantity of meal so given is small, not over one-quarter of a pound daily for each hundred weight of animal. In view

*Texas Sta. Bul., No. 21.

of the results at the Texas Station we would not recommend the use of cotton seed meal in large quantities to hogs for any considerable period of time.

III. The Relative Value of Cooked and Uncooked Feed for Swine.

In the Fourth Annual report of this Station published in 1886 the writer gave the details of ten trials in which cooked and uncooked feed were fed against one another to swine. The results of these trials were, without exception, against the practice of cooking feed. Surprised at our results the reports of other agricultural colleges and experiment stations were examined and found to give practically concordant results. Briefly summarized these, including our own, show as follows:

Relative value of cooked and uncooked feed for swine, as measured by the amount of food required for a given gain.

Whole Corn.

1 trial at Kansas College (Rep., Prof. Agr., '85.)
2 trials at Iowa Agricultural College (Coburn's Swine Husbandry). *Loss by cooking,* 17 *per cent.*

Corn Meal.

9 trials at Maine College (Ann. Rept. Trustees, 1878).
2 at Iowa (Coburn's Swine Husbandry).
2 in Wisconsin. *Loss by cooking,* 17 *per cent.*

Whole Corn and Shorts

2 trials at Wis. station (Fourth Rept.). *Loss by cooking,* 15 *per cent.*

Corn Meal and Shorts.

5 trials at Wisconsin station (Fourth Ann. Rept.) *Loss by cooking,* 1 *per cent.*

Corn and Oat Meal.

1 trial at Mich. College (Bul. 4). *Gain by cooking,* 2 *per cent.**

Barley Meal.

4 trials at the Wis. station (Fourth Ann. Rept.). *Loss by cooking,* 5 *per cent.*

Barley, Rye and Pea Meal.

2 trials at the Ottawa station (Bul. 15). *Gain by cooking,* 1 *per cent.*

Peas.

5 trials at Ontario College (Rept. 1876). *Loss by cooking,* 4 *per cent.*

Potatoes.

1 trial at Maine station (Rept. 1886-7). *Gain by cooking,* 12 *per cent.*

---

*In this experiment the feed was prepared by pouring scalding water on the meal and allowing it to stand before feeding. We can hardly call this cooked feed.

All of these results, except that at Ottawa, with barley, rye and pea meal, and the Maine trial with potatoes, were detailed in our Fourth Annual Report. Our conclusions unfavorable to cooking feed for swine attracted much notice, and comments favórable and unfavorable appeared in the agricultural press. They also brought considerable private correspondence. Some writers declared that it is unreasonable to suppose that a given quantity of cooked feed is less nutritious for swine than the same amount of feed before cooking. Farmers wrote that they had practiced cooking feed and never had their hogs do so well by any other system. Had our experiments stood alone and unsupported so much opposition would have greatly shaken our faith in our conclusions, but the corroborative evidence was too large and varied to be easily set aside.

There were two points in which we had possibly failed. In these trials the feed was cooked by using a steamer — that is, steam was generated in one vessel and forced through a pipe over to the bottom of a second which held the wet feed. The meal was well stirred and always thoroughly cooked. It was barely possible that this form of steaming was not the most satisfactory, though it seemed the best plan that could be devised. The uncooked meal had in all cases been fed dry, a practice not satisfactory as shown by later trials. In most all of these trials our hogs, getting both cooked and uncooked feed, had not made as large amount of gain from a given weight of feed as was shown possible by later experiments. It was such considerations as these and to gain still more experience, that led the writer to undertake the experiments here reported in order to obtain further light on this important subject.

In the experiments here reported the meal was in each case cooked in a large iron kettle or caldron by first bringing the water to a boiling point and then adding a little salt and stirring in the meal gradually until a thick mush or pudding resulted. The boiling was continued for

about fifteen minutes, the attendant stirring constantly to prevent burning. The greatest care and attention was given to making a pudding just as palatable as possible for the hogs.

The animals under trial were always divided into two lots, as even in all respects as possible. To one was given as much of this cooked meal as the animals would eat with relish, care being taken that no feed should be left remaining in the trough. The mush was always given warm at about 100° temperature. With the hogs getting uncooked feed the meal was placed in the feed trough dry and hot water poured over it, stirring with a stick until water and meal were well mingled. It was arranged that the temperature of the mixture should be the same as with the cooked feed, thus giving neither lot an advantage over the other in the temperature of food at feeding time. In the first three trials a third lot of pigs was fed part cooked and part uncooked feed, the quantity being as nearly an equal mixture of the two as the attendant could well make it. In all cases the weights reported are accurately given for the dry meal.

FIRST TRIAL.

Our first experiment was with a lot of 15 full-blood and 6 grade Berkshire pigs, divided into three lots of seven each. Pigs numbered 1 and 2 in the following table were grade Berkshires, those numbered from 4 to 7 inclusive, were eligible to registry. Their previous feed had been corn meal, shorts and milk. On September 21 they were placed in their respective pens, each lot receiving for feed and equal weight of corn meal and shorts. For Lot I all of the grain mixture was cooked. For Lot II it was fed uncooked, being moistened just before feeding time. To the pigs in Lot III was given as nearly as possible a mixture of equal parts of cooked and uncooked meal. As customary with us the several lots were fed on their respective feeds for one full week before the experiment proper began, we believing that this preliminary period is necessary in order

to get the animals filled up and gaining normally. For convenience of study we have grouped the trials into periods of four weeks each.

Table showing the results of feeding cooked and uncooked and a mixture of cooked and uncooked food to pigs. Each period 4 weeks.

LOT I.—COOKED FEED.

	Grain Fed.		Milk.	Weight of Pigs.							Total gain.
	Cook'd.	Un-cooked.		1	2	3	4	5	6	7	
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight Sept. 28	......	......	......	94	116	102	102	85	88	94	......
Period I	920	......	482	36	51	48	37	38	42	40	292
Period II	1,090	......	......	30	40	32	24	27	35	24	212
Period III	1,031	......	......	23	23	26	28	23	29	28	180
Total feed and gain	3,041	......	482	89	114	106	89	88	106	92	684

Lot II.—Uncooked Feed.

Weight Sept. 28	......	......	......	110	116	98	95	85	87	112	......
Period I	......	942	482	41	34	35	38	30	44	48	270
Period II	......	1,154	......	33	25	31	30	24	29	35	207
Period III	......	1,102	......	33	25	34	28	27	34	48	229
Total feed and gain	......	3,198	482	107	84	100	96	81	107	131	707

Lot III.—Part Cooked, Part Uncooked Feed.

Weight Sept. 28	......	......	......	115	110	90	112	105	87	82	......
Period I	498	417	482	37	45	45	51	41	41	33	293
Period II	590	555	......	28	30	28	37	30	31	26	210
Period III	563	529	......	24	35	30	42	27	25	22	205
Total feed and gain	1,651	1,501	482	89	110	103	130	98	97	81	708

SECOND TRIAL.

The pigs used in this experiment were Berkshires eligible to registry. All had been fed corn meal and shorts equal parts by weight before the trial began. Twelve pigs were divided into three lots of four each and given cooked and uncooked feed under conditions similar in all respects to that described in the first trial. The results are embodied in the following table:

Table showing results of feeding cooked and uncooked and a mixture of cooked and uncooked feed to pigs.

Lot I.—Cooked Feed.

	Grain Fed.		Weight and Gain of Animals.				Total gain.
	Cook'd.	Un-cooked.	1	2	3	4	
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning, Sept. 27	....	....	83	81	60	75	....
Feed and gain, Period I (4 weeks)	476	....	39	38	32	23	132
Feed and gain, Period II (4 weeks)	577	....	38	45	31	36	150
Feed and gain, Period III (4 weeks)	564	.. ..	23	36	26	19	104
Total	1,617	....	100	119	89	78	386

Lot II.—Uncooked Feed.

Weight Sept. 27	....	....	86	85	85	62	....
Feed and gain, Period I (4 weeks)	....	467	34	24	28	19	105
Feed and gain, Period II (4 weeks)	....	552	38	30	37	31	136
Feed and gain, Period III (4 weeks)	....	584	26	31	42	26	125
Total	....	1,603	98	85	107	76	366

Lot III.—Feed Part Cooked, Part Uncooked.

Weight Sept. 27	....	....	85	82	77	79	....
Feed and gain, Period I (4 weeks)	247	248	27	42	17	26	112
Feed and gain, Period II (4 weeks)	281	293	40	44	24	24	132
Feed and gain, Period III (4 weeks)	299	328	42	42	23	32	139
Total	827	869	109	128	64	82	383

THIRD TRIAL.

The hogs used in the third trial were cross-bred Berkshire-Yorkshires from registered sire and dam; their previous feed was corn meal, skim milk and shorts. They were divided into three lots of two each and fed under conditions similar in all resperts to those in the other trials.

Table showing results of feeding cooked and uncooked and a mixture of cooked and uncooked feed to hogs.

Lot I.

	Feed.		Weight of Pigs.		
	Cook'd.	Un-cooked.	1	2	Total gain.
	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning, Sept. 28	....	....	131	151	....
Feed and gain, Period I (4 weeks)	335	....	41	39	80
Feed and gain, Period II (4 weeks)	343	....	33	32	65
Total	678	....	74	71	145

Lot II.

	Cook'd.	Un-cooked.	1	2	Total gain.
Weight at beginning, Sept. 28	....	....	143	132	....
Feed and gain, Period I (4 weeks)	....	324	37	35	72
Feed and gain, Period II (4 weeks)	.....	364	38	31	69
Total	.. ...	688	75	66	141

Lot III.

	Cook'd.	Un-cooked.	1	2	Total gain.
Weight at beginning, Sept. 28	....	... .	147	127	....
Feed and gain, Period I (4 weeks)	175	167	37	37	74
Feed and gain, Period II (4 weeks)	196	177	41	31	72
Total	371	344	78	68	156

FOURTH TRIAL.

In this trial pigs 1 and 2 of each lot were Poland Chinas, the others Berkshires, all eligible to registry. Their previous feed had been corn meal, shorts, oil meal and skim milk.

The feed during this trial consisted of two parts corn meal and one part shorts, the methods of preparation and feeding being similar to that of the preceding trials. In this trial only two lots were fed, one getting cooked feed and the other uncooked feed. The trial lasted ten weeks, with the following results:

Table showing results of feeding cooked and uncooked feed to pigs.

	Feed		Weight of Lot I.	Weight of Lot II.
	Cooked.	Un-cooked.	Cooked.	Un-cooked.
	lbs.	lbs.	lbs.	lbs.
Weight at beginning, Nov. 1	....	......	1,027	1,063
Feed and gain, Period I (4 weeks)	1,155	1,321	268	282
Feed and gain, Period II (4 weeks)	1,353	1,467	310	353
Feed and gain, Period III (2 weeks)	696	728	146	144
Total	3,204	3,516	724	779

Weight and gain of individual pigs.

	1		3	4	5	6	7	8	8	10	Av.
LOT I.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Cooked Feed.											
Wgt. at beginning	105	103	99	105	97	108	102	107	93	108	102.7
Gain	73	58	76	84	90	69	72	65	57	80	72.4
LOT II.											
Uncooked Feed.											
Wgt. at beginning	107	108	106	107	92	103	123	101	108	108	106.3
Gain	64	91	100	80	78	64	73	70	84	74	77.8

FIFTH TRIAL.

In this trial pig No. 1 of each lot was a cross-bred Poland China-Berkshire, the others full-blood Poland Chinas, eligible to registry. As in the last experiment the feed consisted of two parts of corn meal and one part shorts, all other conditions being similar to the previous experiments. This trial lasted but two periods of four weeks each. The following table gives the results:

Table showing results of feeding cooked and uncooked feed to hogs.

	Food.		Weight of Pigs.				Total gain.
	Cooked	Un-cooked.	1.	3.	2.	4.	
Lot I.							
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning, Dec. 1st	......	....	148	124	167	150	....
Food and gain, Per. I (4 weeks)	615	....	35	37	51	43	166
Food and gain, Per. II (4 weeks)	677	......	30	31	42	38	141
Total	1,292	......	*65*	*68*	*93*	*81*	*307*
Lot II.							
Weight at beginning, Dec. 1st	....	....	168	135	155	147	....
Feed and gain, Per. I (4 weeks)	....	623	39	39	41	33	152
Feed and gain, Per. II (4 weeks)	......	694.5	35	36	35	40	146
Total	......	1,317.5	*74*	*75*	*76*	*73*	*298*

Let us next condense the results of these tables for the purpose of easier study. To do this we obtain the amount of food required for 100 lbs. gain live weight during each of the periods for the several trials. This result is shown in the following table:

Table showing amount of feed required for 100 lbs. increase, live weight, with cooked or uncooked feed, by periods of four weeks each, and for whole trial.

	COOKED FEED.		UNCOOKED FEED		PART COOKED, PART UNCOOKED FEED.	
	Av. for period.	Av. for whole trial.	Av. for period.	Av. for whole trial.	Av. for period.	Av. for whole trial.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
First trial, Period I (4 weeks)	315*	....	349*	....	312*	....
First trial, Period II (4 weeks)	514	....	558	....	545	....
First trial, Period III (4 weeks)	573	....	481	....	533	....
Average	....	*445*	....	*453*	....	*445*
Second trial, Period I (4 weeks)	360	....	444	....	441	....
Second trial, Period II (4 weeks)	384	....	406	....	434	....
Second trial, Period III (4 weeks)	542	....	467	....	451	....
Average	....	*418*	....	*437*	....	*440*
Third trial, Period I (4 weeks)	418	....	450	....	462	....
Third trial, period II (4 weeks)	528	....	528	....	518	....
Average	....	*467*	....	*488*	....	*459*
Fourth trial, Period I (4 weeks)	431	....	468	....	....	....
Fourth trial, Period II (2 weeks)	436	....	416	....	....	....
Fourth trial, Period III (2 weeks)	477	....	506	....	....	....
Average	....	*443*	....	*451*	....	....
Fifth trial, Period I (4 weeks)	370	....	410	....	....	....
Fifth trial, Period II (4 weeks)	480	....	476	....	....	....
Average	....	*421*	....	*442*	....	....
General averages	....	*439*	....	*454*	....	*448*

* Exclusive of the skim milk fed in this period.

Our general average shows that for the whole five trials 439 pounds of meal after cooking were required for 100 lbs. increase live weight, while 454 pounds of uncooked feed produced the same result. Here is a saving of 15 pounds of meal on 439 through cooking, or 3.4 per cent. For the three trials with part cooked and part uncooked feed the result was intermediate between the two just reported.

The amount of food required for 100 lbs. gain in these trials was remarkably low, and the writer believes cannot be duplicated only under the most favorable circumstances as to animals, feed and condition of feeding, and that not for long feeding periods.

As a result of these trials we may say that under the most favorable conditions we have been able to secure, and with the greatest care in the preparation of the cooked feed, we were enabled to make a saving of 3.4 lbs. of meal for each 100 required when feeding cooked and uncooked meal to swine. With the number of pigs fed on an ordinary farm it would not be profitable to attempt such a saving; in very large establishments it might pay.

IV.—Wheat as a Food for Fattening Hogs.

The steadily falling market value of wheat for several years past has finally brought that grain to a position where it is a competitor with corn as a food for live stock. The following trials were conducted for the purpose of comparing the value of wheat with corn as a food for hogs. The wheat used in these experiments was No. 2 red winter wheat, carefully cleaned, and reduced to a meal by grinding. The corn used was No. 2 western corn, reduced to meal. In both cases the meal was made into a slop by mixing it with water just before feeding time. The pigs used in these trials were Berkshires, eligible to registry. The preliminary feeding trial, which is always a week with us unless otherwise noted, was here six days in duration. The following table shows the results of the first two trials:

Table showing the results of feeding wheat against corn to hogs.

	Feed eaten	Weight of Pigs. 1	2	3	Total gain.
Lot I—Wheat meal.					
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Weight at beginning, March 12	.....	144	95	99	......
Feed and gain, first 5 weeks	503	38	37	27	102
Feed and gain, second 5 weeks	472	39	31	19	89
Total feed and gain	975	......	......	.....	***191***
Lot II—One-half wheat meal, one-half corn meal.					
Weight at beginning, March 12	......	111	125	111	......
Feed and gain, first 5 weeks	521	34	43	37	114
Feed and gain, second 5 weeks	467	27	34	22	83
Total feed and gain	988	.....	......	......	***197***

SECOND TRIAL.

	Feed eaten	1	2	3	Total gain
Lot I—Wheat meal.					
Weight at beginning, March 12	......	125	101	131	......
Feed and gain, first 5 weeks	521	43	22	39	104
Feed and gain, second 5 weeks	533	40	28	38	106
Total feed and gain	1,054	......	......	......	***210***
Lot II--One-half wheat meal, one-half corn meal.					
Weight at beginning, March 12	......	103	116	117	....
Feed and gain, first 5 weeks	521	40	32	43	115
Feed and gain, second 5 weeks	533	37	28	36	101
Total feed and gain	1,054	....	......	.....	***216***

THIRD TRIAL.

In the above table we note that in both cases a mixture of wheat and corn meal did better than wheat alone, though the difference was not very marked; this led us to devise the next experiment, in which there was a third lot of

pigs, these getting corn meal. By this means we can compare corn meal alone with wheat meal to note which has the higher feeding value, when fed separately, and also the results of using a mixture of the two meals.

In this experiment Lot I received wheat meal, Lot II half wheat meal and half corn meal, and Lot III corn meal only. In all cases the meal was mixed with water to form a thick slop just before feeding time. Pig No. 1 in each lot was a Berkshire, the others Poland Chinas, all eligible to registry. Our experiment was divided into three periods of three weeks each.

Table showing the results of feeding wheat meal, corn meal and a mixture of wheat meal and corn meal to hogs.

	Feed eaten	WEIGHT AND GAIN OF PIGS.			Total gain.
		1	2	3	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Lot I—Wheat meal.					
Weight at beginning, March 13	......	262	226	254	.....
Feed and gain, first three weeks	404	33	29	30	92
Feed and gain, second three weeks	418	26	19	26	71
Feed and gain, third thaee weeks	384	26	15	27	68
Total feed and gain	1,206	......	...	......	*231*
Lot II—One half wheat meal, one-half corn meal.					
Weight at beginning, March 13	......	228	267	242	......
Feed and gain, first three weeks	404	25	37	30	92
Feed and gain, second three weeks	432	19	34	31	74
Feed and gain, third three weeks	391	26	31	27	84
Total feed and gain	1,227	......	.. ...	......	*250*
Lot III—Corn meal.					
Weight at beginning, March 13	......	238	235	256	......
Feed and gain, first three weeks	404	30	33	22	85
Feed and gain, second three weeks	434	30	30	29	89
Feed and gain, third three weeks	374	27	18	24	69
Total feed and gain	1,212	......	.....	.. ...	*243*

In order to better understand these tables let us ascertain the feed required for 100 lbs. of gain in each of the trials. This is as follows:

Table showing the feed required for 100 *lbs. of gain with wheat, with half wheat, half corn meal, and with corn meal.*

	Wheat meal.	Half wheat meal, half corn meal.	Corn meal.
	Lbs.	Lbs.	Lbs.
First trial	511	502	......
Second trial	502	488	......
Third trial	522	490	499
Average	*512*	*493*	*499*

We note in every case in these trials that for 100 lbs. increase, live weight, more wheat meal was required than of the mixture half wheat meal and half corn meal. In the third trial the mixture of wheat meal and corn meal was more effective than either wheat meal or corn meal when these two were fed separately.

These trials are too few in number to warrant any general conclusions, but they go to show that for fattening hogs wheat meal is not quite so valuable as corn meal, pound for pound, and that a mixture of wheat meal and corn meal is more efficient than either meal fed separately.

V.—The Value of Pigeon-grass Seed for Swine Feeding.

In the great spring-wheat region of the northwest pigeon-grass is a common weed in the wheat fields, and its seed often forms an appreciable part of the wheat crop. Often the wheat growers do not properly grade their wheat before selling so that this seed finds its way to the mills and elevators where it is separated and accumulates in large quantities. In the effort to determine whether this seed was of value for pig feeding, a quantity was purchased in

the fall of 1893 from Hubbard & Palmer, millers, Mankato, Minn., the price being $4.00 per ton at the mill. This low price shows that pigeon-grass seed is not very highly appreciated by the farmers in the sections where it grows. The seed was fed ground. In a preliminary trial it was found that the pigs did not like this material in the raw state and could only be induced to eat any considerable quantity of it when the ground seed was mixed with corn meal; this objection was quite largely overcome by cooking the seed. Accordingly we planned our experiment to feed one-third pigeon-grass seed meal and two-thirds corn meal, both uncooked, to one lot of pigs. To the next lot was fed about two-thirds cooked pigeon-grass seed meal with one-third uncooked corn meal, while the third lot, used as a check, received uncooked corn meal only. With the cooked pigeon-grass seed we could not feed in the exact proportions stated, owing to the difficulties of measuring out the cooked feed in the proper proportions daily. Our figures give the exact amounts consumed in each case.

The experiment was duplicated with a second lot of pigs under conditions similar to the first lot. The pigeon-grass seed meal was prepared by stirring the meal into a kettle of boiling water to which a little salt had been added, and continuing the boiling for fifteen minutes, the attendant carefully stirring the feed the whole time to prevent burning. The hogs used in the first trial were Poland Chinas and those in the second Berkshires, all eligible to registry. The following table summarizes the results of the two trials:

Table showing the results of feeding cooked and uncooked pigeon-grass seed meal with corn meal to hogs.

	Feed Consumed.			Weight of Pigs.			Total gain.
	Corn meal.	Pigeon-grass. Cooked	Pigeon-grass. Uncooked	1	2	3	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Lot I.—Cooked pigeon-grass seed meal and corn meal.							
Weight at beginning, March 13........	... . .	.... .	.....	255	222	254	....
Feed and gain (5 weeks)........... ...	207	513	. . ..	35	50	50	135
Lot II.—Uncooked pigeon-grass seed meal and corn meal,							
Weight at beginning, March 13	....	....	.. ....	220	243	258	....
Feed and gain (5 weeks)..............	401	....	200	39	36	35	110
Lot III.—Corn meal.							
Weight at beginning, March 13	... ..	....	....	246	231	239	....
Feed and gain (5 weeks)...	601	... ...	.. ....	39	30	47	116

SECOND TRIAL.

	Corn meal.	Pigeon-grass. Cooked	Pigeon-grass. Uncooked	1	2	3	Total gain.
Lot I.—Cooked pigeon-grass seed meal and corn meal.							
Weight at beginning. March 13.....	.. ....	....	....	219	226	249	....
Feed and gain (5 weeks)...	209	452	....	55	38	36	129
Lot II.—Uncooked pigeon-grass seed meal and corn meal.							
Weight at beginning, March 13........	....	....	....	235	235	218	....
Feed and gain (5 weeks)...	255	....	177	23	41	27	91
Lot III.—Corn meal.							
Weight at beginning, March 13	....	....	.. ...	232	258	219	.. ....
Feed and gain (5 weeks)........... ..	598	....	......	30	45	33	108

Reducing the above figures we get the following as the feed required for 100 lbs. increase, live weight, with the several lots:

Food for 100 lbs. increase, live weight—average of two trials.

Corn meal only	585 lbs.
One-third uncooked pigeon-grass seed meal Two-thirds corn meal	566 lbs.
Two-thirds (about) pigeon-grass seed meal One-third corn meal	522 lbs.

The above shows that where two-thirds of the feed consisted of cooked pigeon-grass seed somewhat less of the mixture was required for a given increase than with corn meal alone, while where one-third uncooked pigeon-grass seed with two-thirds corn meal were used a larger amount of feed was required for a given increase.

The above table shows that the best returns for feed was with the lots getting cooked pigeon-grass seed meal and corn meal; that the lot getting uncooked pigeon-grass seed meal and corn meal gave the poorest returns, with corn meal intermediate. Let us next study the total feed consumption. If we add together the total meal consumed by pigs on the same kinds of feed we have the following:

	Total feed eaten.	Feed for 100 lbs. gain.
Lot I, both trials, cooked grass seed meal and corn meal	1381 lbs.	522 lbs.
Lot II, both trials, corn meal only	1191 lbs.	585 lbs.
Lot III, both trials, uncooked grass seed meal and corn meal	1033 lbs.	566 lbs.

The above shows in a most interesting way that the hogs consuming the largest amount of feed during the experiment gave the best returns for the food consumed, while those consuming the least food required the largest amount of feed for 100 pounds of increase, live weight. In all cases in these trials the hogs were fed all of the meal that they would consume, the troughs being cleaned up each feed time. It is evident from our figures that cooking the pigeon-grass seed meal made it more palatable and, possibly, more digestible.

From our preliminary investigations and these trials we

conclude that hogs will not take kindly to a feed where more than one-third of it consists of pigeon-grass seed meal, and that with a ration of one-third pigeon-grass seed meal and two-thirds corn meal somewhat more feed is required for a given gain than with corn meal alone. When, however, the pigeon-grass seed meal is cooked, as much as two-thirds of the ration may consist of this material, and that when two-thirds of the ration is cooked pigeon-grass seed meal and the other third corn meal a gain may be produced with less pounds of the mixture than on corn meal alone.

By comparing the results of these trials with those where wheat meal was fed to pigs it will be found that our pigeon-grass seed meal compares very favorably with that highly prized food article.

These experiments are commended to the attention of those farmers who deliver their wheat to the elevators uncleaned, and thereby receive a lower price for their wheat crop.

RAPE FOR FEEDING SHEEP.

JOHN A. CRAIG.

As the introduction and history of this crop has been amply and ably treated in the publications of the United States Department of Agriculture, this report will be confined closely to our Station experience in growing this plant and feeding it to sheep. Our experience dates from the summer of 1891, and each succeeding year it has been tried with varying success. The first trial of the crop resulted in a fair growth, but just previous to the time that it could have been fed to sheep, the plant lice attacked it and injured it to such a degree that no experiment could be tried that year. Our flock of sheep were turned on it and they ate it though they did not relish it with the lice so numerous. We were unable to do anything to check the ravages of these insects, as they increased with wonderful rapidity during a few warm and dry days.

The next trial resulted in an experience with the wrong variety of rape. There are several varieties of this plant, and with many others we grew, in 1892, a hybrid variety that was practically worthless as a fodder. It flowered and produced seed early in the first season which the true fodder rape does not do. The sheep were turned into it, but there was very little feed for them, as the leaves were small and the stalks large.

The next year, 1893, rape was tried again and its value for fattening sheep was fairly tested. The piece that was grown was comparatively free from lice and those that were on it did not affect it to any noticeable extent.

This summer, 1894, the crop was most satisfactory in every way. About two acres was experimented with in

the different methods of growing the crop and feeding it to the best advantage. The results from the several years' experience that we have had with the crop are embodied in observations that follow.

I. Culture of Rape.

1. THE RAPE PLANT.

The photographs of a typical rape plant and the crop growing in the field which are shown herewith (Figs. 1 and 2) will convey a correct impression of the nature of a plant

IG. 1.—Rape Plant, showing growth of two months on station farm, July to August, 1894.

of the Dwarf Essex variety. It is a member of the same family as the turnip and the radish, and has their peculiar taste, but it grows quite differently. It is like a turnip that

has grown altogether to top. The root is fibrous and has no resemblance whatever to the bulb of the turnip. The leaves grow large, thick and plentiful, and it is these that the sheep eat.

The Composition of the Plant.—Analyses of the plant in a green state show it to contain a great deal of water. Mr. Woll found representative plants from the crop of this year to contain 88.2 per cent. water, and in an analysis made by Dr. Voelcker the percentage of water was 87. In the latter analysis the flesh-forming or nitrogenous constituents were 3.1 per cent., the heat giving and fat-forming constituents 8.2 per cent., and the ash 1.6 per cent. From its analysis it will be seen that in respect to its composition, the plant has no special commendation. The chief value of the crop lies in the quickness of its growth, the amount of feed it produces, the facility with which it may be utilized for sheep feeding, and the fact that the sheep are very fond it.

Varieties of Rape.—There are a number of varieties of rape, and they each have a distinct use. Some are grown for the seed alone—they flower the year they are sown—and others of the fodder variety are used solely for feeding green; these do not produce seed until the second year. There are hybrid varieties between these, but the variety which is the best for feeding is the Dwarf Essex Fodder rape. As a provision against the possibility of sowing the wrong variety it may be well to state that the bird seed rape which is grown for its seed alone has smaller seeds than the fodder rape. Eighteen of them may be arranged on an inch line while only about fourteen of the fodder rape seed will extend over a similar length. The bird rape seeds are of various colors, brown, yellow, or tints of these, while those of the fodder variety are a uniform black. The taste of the bird seed rape is sharp like that of a radish, while the fodder rape seed is milder in flavor and slightly bitter.

After the plants are out of the ground, there is a marked difference in the leaves. The second leaf of the fod-

der rape is like that of a Swedish turnip, being smooth, while those of the bird rape are hairy like the leaves of the young mustard plant. The bird rape grows a hard stalk which soon throws out flowering branches, and it is not long until the small clusters of yellow flowers appear. The fodder rape, on the other hand, grows large leaves and does not show any indication of flowering the first year.

The use of the fodder variety is mainly confined to sheep feeding, though pigs are fond of it and cattle like it. Owing to the economical and easy manner in which the crop may be utilized by hurdling sheep on it, there is every reason for believing that the crop will continue to be considered one specially adapted to them.

2. THE SOIL FOR THE RAPE.

The first trial we made with rape was on soil that was light, friable, and somewhat sandy, without much vegetable matter. The rape made a moderate growth. The next year part of it was grown on soil that was still freer from organic matter and on this the crop was comparatively light, while in a lower piece, richer in vegetable mould, the yield was much better. The last trial was made on land that had never been broken before and the result was the best piece that we have ever grown. Our trials corroborate the general experience that soils rich in vegetable matter, that are warm and friable, will produce excellent crops. The plant is a rank grower and should have a soil enriched by heavy manuring as well as one worked to fine tilth.

3. SOWING.

The crops grown at the Station farm have been mostly drilled, and the drills were level and not raised. As to broadcasting or drilling no direct experiments have been made at our Station and we are not in a position to say which will give the most satisfaction for sheep feeding. When broadcasted the stalks do not seem to grow as large

as in the drilled and they seem to be crisper. The drilling has a special advantage in that it may be cultivated while the crop is growing, and that helps it and also cleans the land. The crop has always been drilled level with us for the reason that ridging does not seem to have any advantages where the main consideration is to tide the crop over a period of drouth. The seed was put in with a Planet Jr. drill.

The Quantity of Seed.—The quantity of seed to sow depends somewhat on the conditions present in each case; it has been our experience that it is best to sow heavier than has been generally recommended. The best results that have been so far obtained were secured by sowing at the rate of about 3 lbs. per acre in drills. When sown broadcast from 3 to 4 lbs. will likely give the best growth.

The Time to Sow.—The greatest certainty in getting a good catch and unchecked growth has been secured by sowing the seed at a favorable time during the third or fourth week in June. When the hot and dry season arrives, the plants are sufficient matured to resist it and the crop is ready to feed at a season when it is most needed. It would be advisable to sow several pieces two weeks apart and in this way a continuously supply of good feed can be obtained. When sown in June the rape will have to be fed during August, though if the first crop were cut about four inches from the ground there would be an aftermath or second growth that would be useful after that time. For the breeding flock a piece should be sown early in June, but for fattening lambs it must be sown about the first week in July with some even later, and the chances taken on it withstanding the drouth.

Sowing The Seed With Other Crops.—The practice of sowing with other crops has been tried with varying success. Sowing it with oats has been stated by those who have tried it to be satisfactory. After the oats are cut the rape grows rapidly. Broadcasting it in the corn after the last cultivation has been recommended, but our experience of this method has not been such as to lead us to commend

FIG. 2. Rape Growing in the Field.— Photographed in August, about two and one-half months from time of seeding

FIG. 3.--Feeding Rape to Breeding Ewes on the Station Farm.

the plan. The rape does not make much growth while the corn is standing and the time of the removal of the latter is so late that the rape does not have time to grow sufficiently to make satisfactory fall feed.

II. Harvesting the Rape.

As far as we know the only two practical methods of utilizing the rape crop for sheep feeding are employed when the crop is in a green condition. They consist in either cutting it and feeding it to the sheep or turning the sheep on a piece of it and allowing them to eat it as they desire it. It is easy and desirable to adopt the first method in the instance of the breeding flock for the ewes and rams and possibly for the lambs; but for fattening sheep allowing them to feed it off is safe, economical, and in no way troublesome.

Cutting the Rape.—This summer half an acre of good rape was measured off with the purpose in view of cutting it and feeding it to the breeding flock. The rape was cut daily as needed and fed twice each day to all the breeding ewes. The ewes were kept most of the time on a small piece of pasture, and the rape was cut and thrown over the hurdle to them. The rams were fed mostly once a day, and the same course was adopted in the instance of the ewe lambs. On August 16th the rape was first fed and cut and at that time there were 62 ewes, 26 ewe lambs and 5 rams receiving it in the manner described. The sheep were given from 300 to 350 lbs. daily with no grain and a small amount of pasture in addition. These figures afford the means of forming an indefinite idea of the amount of food there was in the half acre for the sheep; a more accurate estimate can be made from the weight of rape that was cut from the piece.

The Amount Cut from a Half Acre.—The first cutting was done on August 16th and continued until September 17th, just about one month. The rape could have been cut quicker, but it was delayed so as to get as much feed as

possible for the breeding ewes. From the half acre there was cut 9.75 tons of green rape, or it yielded at the rate of 19.5 tons per acre.

The rape was cut as close to the ground as possible and notwithstanding this, it soon began to send out a second growth. This was also cut and fed, but owing to the lateness of the season, it was not considered worth the trouble to cut it carefully enough to weigh it. If the rape had been cut earlier, the second growth would have supplied considerable feed, though it would not likely be as nutritive as the first cutting.

Different Methods of Cutting.—A trial was made in a small way of cutting the rape in different ways. Twenty rows, fifty feet long and thirty inches apart, that had been sown June 18th were selected. When the rape had grown sufficiently to be ready for the first cutting (August 29th), five of these rows had the leaves twisted off the stalks eight inches from the ground. At the same time five other rows were cut eight inches from the ground, five more four inches from the ground, and the remaining five were cut as close to the ground as possible.

On the 29th of September, one month from the first cutting, the rows that had been twisted as well as those that had been cut eight inches from the ground, were ready to be treated in the same way again. This was done, while the other two of the series were left undisturbed. On November 8th all the rows were cut close to the ground so that the yield from each method could be compared.

The results obtained were as follows:

Method of Treatment.	Amount Aug. 29.	Amount Sept. 29.	Amount Nov. 8.	Total.
	Lbs.	Lbs.	Lbs	Lbs
Five row twisted 8 inches from ground..	253	157¼	159½	569¾
Five rows cut 8 inches from ground.......	273	206½	153½	633
Five rows cut 4 inches from ground......	293	(not cut)	431½	724½
Five rows cut close to ground.	343	(not cut)	296	639

These rows were carefully selected and the results are trustworthy and suggestive as far as they go, but as they are the outcome of only one test they cannot be accepted as conclusive.

Comparing the practice of twisting off the stalks with the cutting, the results are in favor of the latter; also in respect to the despatch with which the work may be done the cutting has the advantage. It was noticed that the sprouting of the new shoots from the stalks treated in these ways was quite different. Those that had been twisted made a scattered and open growth, while those that had been cut sent out a great many small shoots that formed a close, compact head. A comparison of the two methods, cutting four inches from the ground and cutting close to the ground, shows a very decided advantage from cutting the stalk four inches above the ground. A difference of 85½ lbs. on a small piece of rape—about one one-hundredths of an acre—would make an appreciable difference when applied to an acre.

It may be interesting to note, though it is hardly legitimate to do so owing to the small amount tried, that the two cuttings four inches from the ground yielded at the rate of 36 tons per acre. Even if that is close to 90 per cent. water, it represents a large amount of feed for sheep. This rape, when cut, had not made quite as good growth as the rest of the field that was being cut and fed to the ewes, so that the large amount of fodder obtained must be credited to the treatment and not to an exceptional crop.

III.—Fattening Lambs on Rape.

When lambs are being fattened on rape it is customary to use hurdles or movable fencing. By this means the lambs may be given definite areas of fresh rape at frequent intervals. Although there is not much danger when the lambs are turned into the field to eat it at will, yet it is much the safer method to limit the quantity they shall receive.

SCALE OF ½ INCH TO THE FOOT.

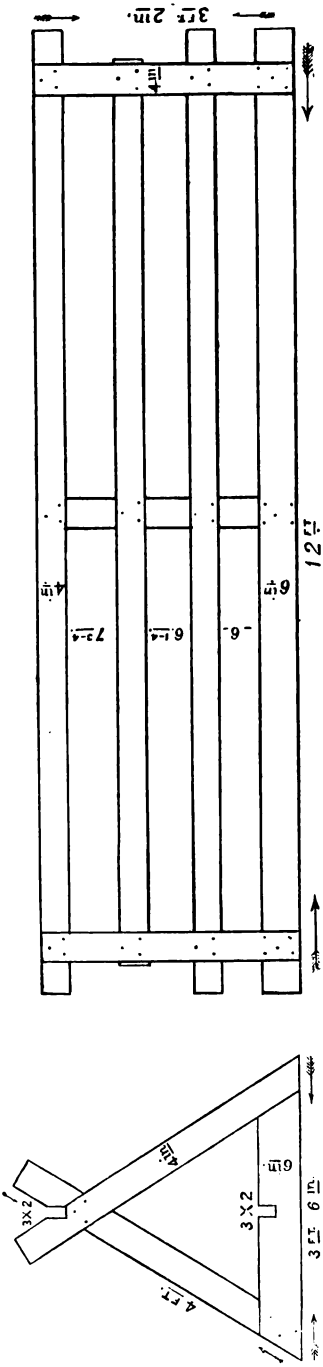


FIG. 4.—Sketch of hurdle used in feeding sheep on rape.

There is some danger from bloating and to prevent this the best means is to provide hurdles. The area that should be given the sheep depends entirely on the number that is to be fed, but after one or two trials of small pieces the feeder can generally tell how much they should be given.

A Cheap and Useful Hurdle.—The hurdle appearing in the sketch, Fig. 4, is in general use for this purpose and has been employed on our station farm for some years past; it has given good satisfaction for sheep fencing and for pig paddocks. The material used for the hurdles is one-inch pine or hemlock. The lower piece in the panel is six inches wide, the rest are four. The panels are 12 ft. long and 3 ft. 2 in. in height; the pieces into which the panels fit are 4 feet high and 3 feet 6 inches wide at the base, and the ends meet so as to form an equilateral triangle. In erecting the fence the ends of the panel fit into the notches in the end pieces.

1. FIRST TRIAL OF RAPE FOR FATTENING LAMBS.

On October 13th, 1893, sixteen wethers, eight of which had been shorn and the remaining eight unshorn, were hurdled on seven-tenths of an acre. The week previous to this the wethers had been on a poor piece of rape and had received oats and pasture in addition. When the feeding started, October 13th, the lambs were getting ½ lb. of oats per head daily. After a week's feeding on this the grain ration was changed to one-half corn and one-half oats, by weight, and this mixture was continued until the sheep were taken off the rape. About one-half pound per head of this mixture was fed daily. The wethers had, in addition to the three-quarters acre of rape, a very small strip of waste pasture, too small to be worth calculating.

Food Eaten and Gain Made.—At the end of twenty-five days, ending November 7th, the sixteen wethers had eaten the seven-tenths of an acre of rape. They had also eaten in that time 153½ lbs. of oats and 97½ lbs. of corn.

When the wethers were put on the rape October 13th

they weighed a total of 1,260 lbs., and when they were taken off, November 7th, they weighed 1,409 lbs.; *i. e.*, a gain of 149 lbs. in 25 days, or a weekly gain of 2.6 lbs. per head.

Considering the trial as a commercial transaction, the oats may be charged at $18.00 per ton or .9 cents per lb., and the corn at $15.00 per ton or .76 cents per lb., making the cost of the grain $2.12. Valuing the wethers at 3½ cents per lb., their actual cost when put on the rape, and 4 cents per lb. at the end of the trial, which price they brought in the local market, the seven-tenths of an acre was worth about $10.14, or at the rate of $14.48 per acre.

2. SECOND TRIAL OF RAPE FOR FATTENING LAMBS.

On August 15th, 1894, a piece of rape exactly one-half acre was measured, and 22 wethers were turned into it. One died shortly afterwards from inflammation of the lungs due to exposure, leaving the number twenty-one. The rape had been sown June 18th, at the rate of 3 lbs. per acre in drills 30 inches apart, and had received two cultivations July 3rd and 9th. In addition to the rape the wethers were given daily an hour's feeding on ordinary blue grass pasture. For first four weeks they received ground wheat as a grain ration. At the end of that time the ration was made 2 parts ground wheat and 1 part oats, and this was continued for five more weeks. During the remaining or last week the grain mixture consisted of 1 part oats, 1 part wheat and 1 part oil meal by weight. The amount of grain fed per head daily was about one-half pound at the beginning and about one and one-half pounds at the end of the ten weeks.

Gain in Weight.—At the end of the ten weeks the twenty-one wethers had eaten the one-half acre of rape. When put on it they weighed a total of 1622 lbs. and when taken off a total of 2035½ lbs. or total gain in ten weeks of 413½ lbs. which amounts to within a small fraction of 2 lbs. per head per week.

It is important to observe that the first five weeks of feeding was carried on during the hottest and driest period of the year. Another consideration of equal importance is the fact that the lambs had just been weaned from their dams. To understand the influence of these two things, if we divide the total period of ten weeks into two periods of five each, we find that during the first period the lambs gained only 1.06½ lbs, or about one pound per head weekly; while during the second period of five weeks, they gained 307 lbs. which is within one-tenth of 3 lbs. per head weekly.

They received about two-thirds more grain during the second period than they did during the first, but undoubtedlo one of the chief influences bringing about this difference was the condition before mentioned.

The Value of the Rape.—Valuing the wheat that the lambs ate at 50 cents per bushel or $16.60 per ton, and the oats at $18.00 per ton and oil meal at $25.00 per ton, the cost of grain food amounts to $12.46. If the wethers are valued at 3 cents per lb. when they were put on they would cost with their feed $61.12, and valuing them at 3½ cents per lb when taken off there would be a balance of $10.12 cents for the half acre or at the rate of $20.24 for an acre.

It will be interesting to know that the half acre that was fed to the wethers was separated from the half acre that was cut only by hurdles, and that the two pieces were similar in all respects as far as we could discern. The half acre that was cut yielded 9¾ tons, so that it is a fair estimate to say that this amount of rape and 1,439.8 lbs, of grain produced 413½ lbs. of mutton.

3. THIRD TRIAL OE RAPE FOR FATTENING LAMBS.

When the wethers that were used in the second trial had completely eaten the rape on the half acre, they were put on a small piece that had been sown broadcast at the rate of 4 lbs, per acre on July 6th. Owingto the exceptionally dry season the rape seed lay dormant in the soil much

longer than usual, and when the plants did appear above the ground the exceptionally hot and dry season checked its growth for several weeks. It was not until October 24th that the rape was in condition to feed. A small piece containing one-tenth of an acre was measured. It had made but a very moderate growth compared with that which had been drilled two weeks earlier.

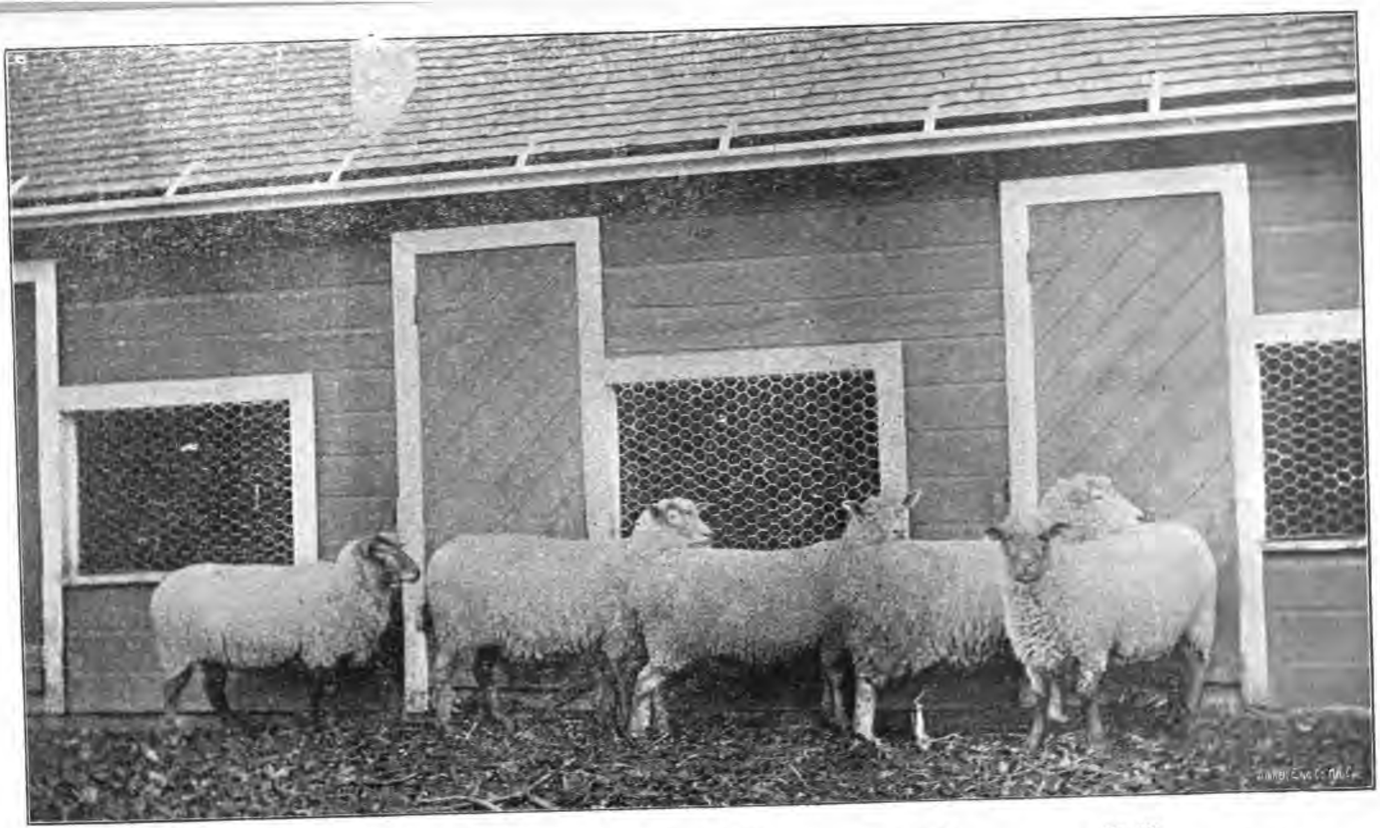
The Grain Eaten and Grain Made.—The twenty-one wethers were hurdled on this for two weeks beginning October 24th and extending to November 7th. They had in addition the run of a pasture field for a short while each morning and were also fed a grain mixture consisting of ground wheat, oats and oil meal, of which one part of each by weight was fed. During the two weeks the twenty-one wethers ate 160 lbs. ground wheat, 160 lbs. oats, and 160 lbs. oil meal, making a total of 480 lbs. or 1.6 lbs. of grain per head daily, costing a total of $4.72.

When the wethers were first hurdled on this pasture they weighed a total of 2,035½ lbs. and when they had completly eaten it two weeks later they weighed 2177½ lbs. a gain of 142 lbs. or a weeky gain per head of 3.3 lbs. This high rate of gain was undoubtedly largely contributed to by the heavy grain feeding of the wethers, the pasture they received and in some degree to their previous management. It is an indication of the gain that can be made from rape feeding under favorable circumstances.

4. PRECAUTIONS NECESSARY IN FEEDING RAPE.

When the sheep are hurdled on rape there are two dangers to guard against, namely, bloating and diarrhœa. When first turned in it the sheep are apt to eat too much and as a consequence it causes bloating. The best way during the first week of feeding is to only allow the sheep on the rape for three or four hours daily and then under watch. For bloating a good remedy is liquid ammonia, one teaspoonful, in three times as much water. This should be repeated every hour or so until the swelling has become reduced. In cases so severe as to require instant treatment, the trocar and

FIG. 5.—Sheep Being Fed on Rape. The method of erecting the hurdle sketched in Fig. 4, is shown in the left corner of the photograph.



No. 441 No. 368 No. 139 No. 434 No. 395

FIG. 6.—Shropshire Grade Ewes Used in Breeding Dorset Down Grades. No. 368 is dam of lamb 1329 (Fig. 11) and of the two ewes Nos. 1006 and 1007 (Frontispiece). No. 434 is the dam of lamb No. 1332 (Fig. 11) and the two ewes Nos. 390 and 403 (Frontispiece). No. 139 is dam of the lambs Nos. 1311 and 1330 (Figs. 10 and 11). No. 441 is dam of lamb 1334 (Fig. 10), and No. 395 is dam of lamb No. 1373 (Fig. 10).

canula should be used. This is an instrument like an awl with a tube covering it; when it is inserted into the highest point of swelling on the left side the tube may be left communicating with the stomach and through it the gas escapes. It should not be used, however, until the trouble has advanced so for as to place the life of the sheep in immediate danger.

The wethers should have a piece of pasture adjoining the rape field and on it they should be allowed to graze at will. If this arrangement is not possible they should be turned into a pasture field for an hour or so each morning before going on the rape. This will be found to check any diarrhœa or scouring that may have started and prevent it from again occurring.

BREEDING EARLY LAMBS.

JOHN A. CRAIG.

In the first week of June, 1891, the writer instituted some experiments for the purpose of testing the methods recommended to induce breeding ewes to take the ram earlier than the customary time so as to have lambs to dispose of early in the winter. Twenty-six Shropshire grade ewes were experimented with. Flushing the ewes was given a thorough trial. For five days the ewes were kept in dry hay, and after that for a period of four weeks they were fed green clover in abundance. This method was unsuccessful. For two weeks in July the ewes were again put on dry feed, consisting of oat-straw, and then for two weeks more they were fed green clover. This trial was also unsuccessful. Driving the ewes on the road each day for a week was tried also without results. As the cold weather of fall is the usual forecast of the breeding season it was thought that keeping them in a cold building would produce the desired results. The average temperature of the building was made to be 55° Fahr. After two weeks under such conditions the experiments were abandoned.

Believing that nothing could be accomplished by these methods attention was directed towards the Dorset breed of sheep. The pure-bred Dorset ewes in the Station flock had shown that they possessed the characteristic common to the Dorset of breeding at any time when not pregnant. It was this that led us to investigate the question whether or not a pure-bred Dorset ram would transmit this feature to his get in the first cross.

EWES SELECTED AS FOUNDATION STOCK.

For this purpose nine grade Shropshire ewes were bred to an imported Dorset ram. They included few of those that had been in the trials previously mentioned, so that there was no likelihood of their possessing the characteristics that we hoped to secure through the use of the Dorset.

The ewes (Fig. 6) were the result of about ten years' breeding on a Merino foundation with Shropshire rams. The photograph from life which is presented herewith shows the ewes to be of common type, in no way remarkable for fleece or form. They had proven to be good breeders and had reared good lambs during the time they had been in the flock, but aside from that and their usefulness they possessed no merit that call for special mention. The ewes all had full mouths at the time they were bred, and nothing further than that is known as to their age, as they were purchased and not bred on the Station farm.

The first weights we have of these nine ewes include those of five of them that were four or five years old, the others were aged.

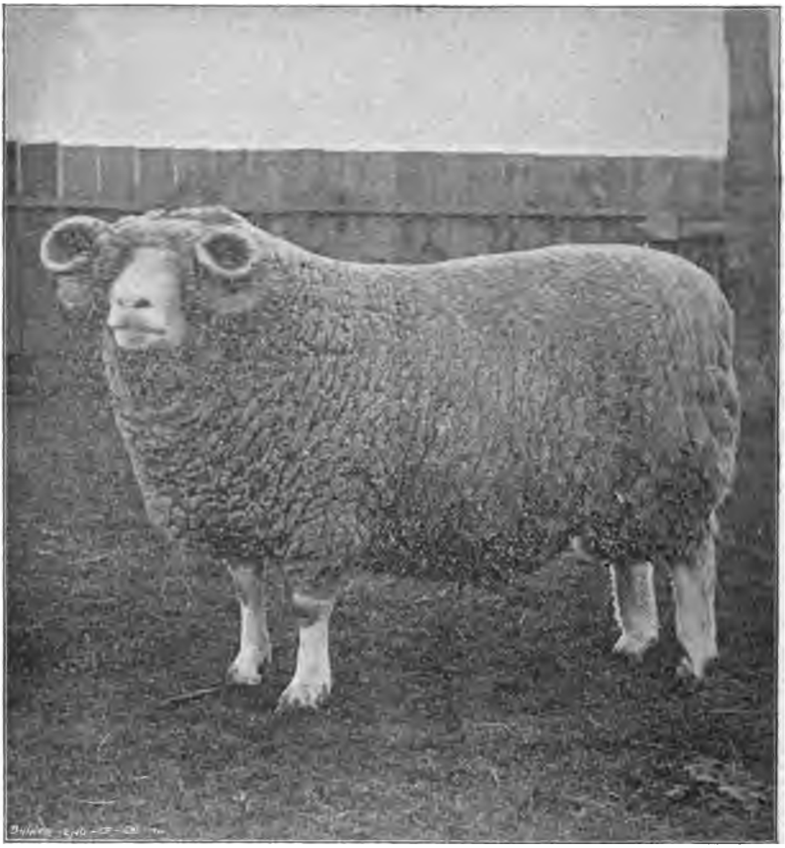
1891, July 28th, nine averaged 116 lbs. in live weight.
1893, Nov. 23d, three averaged 156 lbs. in live weight.
1894, Nov. 15th, two averaged 184.5 lbs. in live weight.

The wool on these ewes would mostly class as medium combing, though some of it would grade as coarse combing. The fibre is coarser than that of the average Shropshire grade, but it is similar in length and strength. The fleeces of most of them are faulty in being so open, due principally to the need of density and not because of any lack of thrift.

1892, May, the nine ewes averaged 7.5 lbs. unwashed wool.
1893, April and May, three ewes averaged 8.8 lbs. unwashed wool.
1894, April, three ewes averaged 8.5 lbs. unwashed wool.

THE DORSET USED AS A CROSS.

The ram used (See Fig. 7) on these ewes was purchased in Canada, and had been bred in Somersetshire, England, by Culverwell Bros. This ram is a satisfactory representative of the best type of this breed, as may be observed in the photograph which shows the ram in rough field condition.



FG. 7.—Pure bred and Imported Dorset Ram. St. Cuthbert, 2074 D. H. R. Lambed February, 1890. Bred by Culverwell Bros., Bridgewater, England. Weight Nov. 15th, 1894, 268 lbs. Average weight of unwashed wool shorn, (3 years) 6.5 lbs.

He is better than the general average of the breed in the quality and density of the fleece and in the absence of any roughness or coarseness in form. The ram shows the evidence of a robust constitution. He is deep and wide

chested, round ribbed, and altogether a sheep of sturdy type. The fault in the form of the sheep is a narrowness of the hind quarter. The wool is exceptionally fine for a sheep of this breed, and it has the other very desirable quality of being dense. There is not that coarseness of horn and bone that is oftentimes observable in those of this breed. As this ram was never fed beyond a condition desirable for breeding purposes, the weights are those that have been taken when the sheep was only in light condition.

1893, Jan. 4th, when within 1 month of 3 years old, 242 lbs.
1894, Nov. 15th, when about 4 years old, 268 lbs.

The wool of this sheep is comparatively fine in fibre and also bright and soft. The fineness is retained over all parts with the exception of a slight tendency to hairiness on the thighs. The wool would class as medium combing on the market. The fleece is dense, and as the fibre is about three inches long it is clear that the lightness of the fleece is attributable to the absence of yolk.

1892 and 1893, average 6.1 lbs. unwashed wool.
1894, April, weight of fleece, 7 lbs. unwashed wool.

THE FIRST CROSS DORSET DOWNS.

The first lambs sired by this ram and out of the ewes previously described were dropped mostly in March, 1892. There were only two ewes that lambed after that month. There was one instance of triplets, six of twins and two of singles, or seventeen lambs from nine ewes. The wethers being sold, there were nine ewe lambs remaining. The ewes shown in the frontispiece are all that are at present in the flock. They were two years and seven months old when the photograph was taken.

These Dorset Down ewes (frontispiece) show in form and features many of the qualities of their ancestors. On the whole the Dorset ram has had most influence in determining their qualities. With the photograph to refer to it is hardly necessary for us to say that these ewes are of ex-

cellent mutton form and possess valuable merits in addition to having the desirable characteristics of breeding in time to drop early winter lambs. The ewes are of medium size compared with most mutton sheep, but are very symmetrical and compact, as their weights indicate. They are short legged and are especially round-bodied, and closely knit in frame. Only two of the ewes have horns of any size. The color of the faces and legs of most of them is pure white while others show varying shades of brown

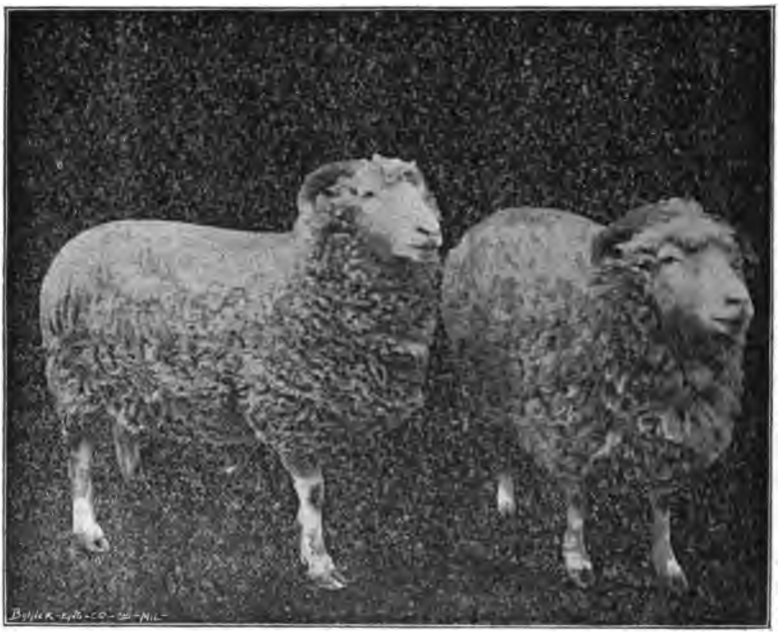


FIG. 8.—Pure bred and Imported Dorset Ewes. Photograph of Ewes taken from the Statio flock for comparison with the grades in frontispiece. Lambed February, 1890. Photos. taken in 1893.

The first weights were taken at the time they went into winter quarters when they were about a year and eight months old. At this time three of them had lambed, three were in lamb, and three had been served a few weeks previous.

1893, Nov. 23d, nine shearling ewes averaged 153 lbs.

1894, Nov. 15th, seven 2-year old ewes averaged 185.5 lbs.

The wool would class as medium combing in the market. It is bright, soft and strong. The fleeces on the ewes are

dense, and most of them are covered with wool Three fleeces from these sheep were sent to the World's Fair with several others, and as an award was obtained on these it will be interesting to give the score of the judge, Mr. Charles F. Avery. The full score allowed for density was 16 points; two of these fleeces obtained 15 and the other 14.8 points. For evenness and fullness of covering 20 points were allowed, and these fleeces scored 18.9, 18.2 and 18.2 respectively. Brightness and softness on the official score were allowed 14 points. One fleece scored 13.5 and the other two 13 points. For character and fineness 16 points were allowed, and the fleeces all obtained full marks on this. Strength and elasticity included 14 points, and two of the fleeces scored 12.1 and the other 12.8 points. For evenness of quality of wool all over 20 marks were allowed and two of these fleeces obtained 19 points and the other 18.9 points. The total number of points obtained was 100, and of that number one fleece scored 94.9 points and the other two each 93.3 points. These scorings by an expert judge will give a satisfactory idea of the quality of the wool. They cannot, however, give any impression of the most valuable character of the fleeces of many of them, for the reason that the density cannot be indicated. The average weights of the fleeces have been as follows:

1893, April, the nine shearlings averaged 7.1 lbs. unwashed wool.
1894, April, the eight ewes averaged 10.8 lbs. unwashed wool.

BREEDING THE FIRST CROSS DORSET DOWN EWES.

When these ewes were about one year and four months old June 16th, 1893, they were put in a small field having three or four acres of pasture and the Dorset ram before described was allowed to run with them. The ewes were not fed anything in addition to the pasturage they received. A ewe was bred on June 22d, the first to be served and by the 9th of July they had all been bred for the first time. Three of the ewes were served the second

time, and the three others were bred at the regular fall season, as they did not become pregnant at the same time as the others. The ram was allowed to run with the ewes the most of the time. They had to be separated after a time, as the intense heat and exertion made it necessary to give the ram better care and feed than the ewes were receiving.

THE WINTER LAMBS.

On the 16th of November the first lamb arrived, the ewe giving birth to a single ewe lamb. On the 18th of the same month another ewe lambed, dropping twins, of which one died owing to weakness. Another ewe lambed Nov. 24th, giving birth to twins, and both are living. The next ewe to lamb dropped a single lamb on December 21st. A premature birth occurred in the instance of one of the ewes considered to be due to an injury received while running in a rough pasture field. Three of the ewes about the latter part of October were bred again as they had not become in lamb in June as was inferred from the fact that they had passed several periods. As they were carefully watched and the ram with them most of the time, it is inexplainable why they passed over the time they did without giving evidence of not being in lamb.

No special preparation was made for the winter lambs in the way of warm quarters. The ewes lambed in pens that had been constructed with the object of securing as much warmth as possible so as to make comfortable quarters for ewes when lambing in the early spring. As soon as the lambs were about a week old they were put in pens with their dams, and their quarters were made as dry and warm as possible. It is necessary to have quarters specially warm and dry for the lambs if they are to make satisfactory growth.

These lambs show the Dorset traits very strongly as would be expected from the fact that they are second cross Dorsets. In addition the four first cross Dorset Down ewes were bred to their own sire. This was done because there

were only a few of those ewes to breed, and it would hardly have been advisable to have purchased another ram specially for them. The lambs all had horns and were all pure white, with the exception of one that was mostly black over the body with a few white spots. As there were only two wether lambs to be sold they were not prepared for market other than to give them ordinary care. When they were about three months old they each weighed 65 lbs. live weight. The other lambs were retained in the flock for breeding purposes and when two of the ewe lambs were weighed Nov. 15th, 1894, they weighed 109 lbs. They did not make as satisfactory growth as those that had been dropped the succeeding spring. One of the lambs with its dam is shown in Fig. 9.

FIG. 9.—Dorset Down Winter Lamb. Photograph taken December, 1893. Ewe is a first cross Dorset-Down, and the lamb a second cross Dorset Down, lambed Nov. 18th, and about four weeks old when photographed.

The chief point of the experiment up to this time lies in the fact that the characteristics of the Dorset to breed fully three months earlier than other breeds is transmissible through the male line to the first cross. This suggests an economical and commendable method of establishing a flock for breeding early lambs.

It has been inquired whether these ewes would breed twice a year similar to the Dorsets. This has not been actually determined, though it would seem that they would breed at any time when not already in lamb. It is very doubtful if it would be advisable to breed ewes twice a year even where the conditions are made as favorable as possible for the ewes. It might be done with success when the lambs are taken from the ewes when they are thirty or forty days old and the ewes fed well, but that implies conditions of market and management that are far in the fore of those that exist in our best sheep farming districts. The rearing of one crop of winter lambs is in itself a comparatively new industry in America, and though it has developed into a profitable feature of the sheep market in the large cities in the eastern states it has no pronounced recognition as yet in the markets of the western cities.

DORSET DOWN SPRING LAMBS.

In the fall of 1893 nine Shropshire grade ewes were again bred to the Dorset ram St. Cuthbert. These ewes are shown the photograph and the lambs from them this spring are shown in another. Three of the ewes were included in those that had been bred to the Dorset the year previous. It mill be seen that these ewes are of a grade common to flocks that have had a Shropshire ram at their head for a few years.

From these nine ewes thirteen lambs were dropped. There is nothing of special importance to record at this time in reference to these lambs further than to say that they have made exceptional growth and that they promise to surpass the aged ewes of this breeding that are already in our flock. The lambs were dropped mostly in March,

and when weighed Nov. 15th, 1894, then about eight months old, the average weight of eleven of them was 120½ lbs. The heaviest weighed 143½ lbs. and the lightest 98 lbs. It will be seen in the photographs (Figs. 10 and 11) that these are of exceptionally good mutton form and that there is reason to believe that they will develop into sheep of more than ordinary merit.

FIG. 10.

FIG. 11.

FIGS. 10 and 11.—Dorset Down Spring Lambs. Sired by pure bred Dorset ram (Fig. 7), and out of grade Shropshire ewes (Fig. 6). Dropped March, 1894. Average weight of the six that are out of ewes referred to, 126.5 lbs. Nov. 15th, 1894.

FALL SHEARING LAMBS BEFORE FATTENING.

JOHN A. CRAIG.

The experimental work done in this direction extends over four expriments, two of which have been already reported. The chief variation in the experiments of each year consisted in changing the time the fall shearing was done. The differences have been as follows:

First experiments: Lot I, shorn December 12th, 1890: Lot II, left unshorn.
Second experiment: Lot I, shorn November 4th, 1891: Lot II, left unshorn.
Third experiment: Lot I, shorn October 14th, 1892: Lot II, left unshorn.
Fourth experiment: Lot I, shorn October 6th, 1893: Lot II, left unshorn.

I. FIRST FXPERIMENT: SHEARING IN DECEMBER.

As the account of this experiment appears in full in the Eighth Annual Report it will not be necessary to discuss it here further than to say that there was nothing gained by shearing the wethers in December; for those shorn at that time and again when the fattening was completed sheared in both clippings a total of about two pounds less washed wool than those that had been left unshorn in December, and in addition the latter made two and seven-tenths pounds more total gain than the wethers that were fall shorn· the cost of 100 lbs. of gain was $4.70 in the fall shorn and only $4.40 in the instance of the unshorn.

2. SECOND EXPERIMENT: SHEARING IN NOVEMBER.

Results of the experiment in November shearing is given in the Ninth Annual Report of this Station. Some slight advantage followed from shearing at that time. The wethers that were shorn in the fall made a total of 7

pounds more gain than those that were left unshorn. The cost of the gain in the instance of the latter was $4.17, as against $4.44 in the instance of the fall shorn sheep.

The chief point to be observed in this trial was that the removal of the fleeces at that time has a favorable influence on the rapidity with which the sheep fattened. During the first eight weeks of the experiment the three shorn wethers gained 17.5 lbs more than the unshorn in the same time. During the second eight weeks or last half of the experiment they made a total of 10.5 lbs. less gain than the unshorn. In the first eight weeks the shorn wethers ate 101.75 lbs. more fodder, 9.75 lbs. more grain and 117 lbs. more roots than the unshorn, and during the second eight weeks or last half of the experiment they ate 32.75 lbs. more fodder, 10.75 lbs. more grain and the same quantity of roots. From these figures it will be seen that the shorn wethers made their greatest and most economical gain in comparison with the unshorn wethers during the first half of the experiment.

3. THIRD EXPERIMENT: SHEARING IN OCTOBER.

In the third experiment the shearing was done October 14th. As this experiment has not been previously reported it will be necessary to add fuller details than those given in the proceding.

Ten grade Shropshire wethers were divided into Lots I and II, weighing at this time 404.5 and 401 lbs. respectively. Lot I was shorn Oct. 14th, and Lot II was left unshorn. As it was too early in the season to begin shed feeding, the wethers were pastured in the same field and not given any grain until shed feeding began on Nov. 11th.

The ration fed to both lots when the shed feeding was started consisted of mixed hay, rutabagas and grain. The hay was not cut, roots were pulped and the grain was fed whole. During the first five weeks the grain consisted of whole oats; then it was changed to three part oats and one part whole corn by weight, and so continued for two weeks; a change was then made to two parts oats and one

part corn by weight and this grain mixture was fed for two weeks. From this time until the conclusion of the experiment, an interval of six weeks, the grain mixture consisted of two parts whole oats, one part whole corn, and one part oilmeal, by weight.

In estimating the cost of rations, the following average market prices for our state have been used: Mixed hay $8 per ton, rutabagas $2 per ton, oats $18 per ton, corn $15.20 per ton, and oilmeal $25 per ton.

One pound samples from all of the fleeces were washed with soap in water at a temperature of 120° Fahr. to determine the difference in the amounts of yolk in the fleeces.

Table of results from experiment in fall shearing, October 14th.

	Lot I. 5 wethers fall shorn	Lot II. 5 wethers unshorn	Difference in Favor of Fall shorn.	Difference in Favor of Un-shorn.
	lbs.	lbs.	lbs.	lbs.
Weight Nov. 11, shed feeding started	405	424 5	....	19.5
Weight Feb. 24, shed feeding ended	630.5	635	....	4.5
Gain in 15 weeks	225.5	210.5	15	....
Average weekly gain per head	3	2.8	.2	....
Total quantity of unwashed wool shorn	35.1	33.9	1.2	....
Total quantity of washed wool shorn	23.3	20.1	3.2	....
Per cent. shrinkage in scouring	35	41	6	....
Per cent. shrinkage in fall shearing	44	....	....	....
Per cent. shrinkage of spring shearing	26	....	....	....
Hay eaten	907.25	902.25	....	5
Rutabagas	601.25	607.25	8	....
Oats	694	728.35	34.35	....
Corn	209.9	225.05	15.1	....
Oilmeal	132 9	140.5	7.6	....
Cost of food	$13.79	$14.09	.30	....
Cost of 100 lbs. gain	$6.11	$6.67	.56	....

1. The daily ration of each fall shorn whether in Lot I was 1.72 lbs. of hay, 1.15 lbs. of rutabagas and 1.97 lbs. of

grain mixture consisting of oats, shelled corn and oilmeal costing 2.62 cents for each sheep daily, the daily gain per head was .42 of a pound. In the period of fifteen weeks the lot of five gained 225.5 lbs.

2. The daily ration of each sheep left unshorn in Lot II was 1.71 lbs. hay, 1.15 lbs. rutabagas and 2.8 lbs. of grain mixture consisting of oats, corn, and oilmeal costing 2.68 cents for each sheep daily; the daily gain per head was .40 of a lb. In the period of fifteen weeks the lot of five gained 210.5 lbs.

3. The results of the fall shearing are in some respects favorable to the practice. The fall shorn wethers made slightly the cheaper gain, as the cost of 100 lbs. gain in the one instance was $6.11, and in that of those that were not shorn in the fall it was $6.67. The fall shorn wethers also made a greater gain of 15 lbs., of which 3.2 lbs. is due to their heavier clip of wool.

4. In this trial the effect of the shearing in hastening the maturity of the sheep appears to be similar to that of the previous experiments. If the time over which the experiment extended is divided into two periods of eight and seven weeks, respectively, it is shown that the gain of the fall shorn wethers in comparison with the others was much greater during the first period than during the second. During the first period of eight weeks the five fall-shorn wethers gained a total of nineteen pounds more than those that were unshorn. During this time the unshorn lot also ate 18 lbs. more grain, 5 lbs. more roots and 24 lbs. less hay than did the wethers that had been fall shorn. In the second period extending over seven weeks, the fall-shorn wethers made 4½ lbs. less gain than those that were unshorn. The unshorn during the second period, however, ate 39.5 lbs. less hay; 19 lb. less grain and the same quantity of roots. These facts indicate that the removal of the fleece hastens the fattening up to the time that the wool has become half grown.

5. The fall shorn wethers sheared 1.2 lbs. more unwashed wool or 3.2 lbs. more washed wool than those that

were not shorn in the fall. The fibre of the wool from the two clippings in fall and in spring is much shorter than that from the sheep that were shorn in the spring, hence the latter would bring more per pound.

4. FOURTH EXPERIMENT: SHEARING IN OCTOBER.

In the fourth trial sixteen Shropshire wethers were divided into two lots. Lot I was shorn Oct. 6th, 1893, and Lot II was left unshorn. At the beginning Lot I weighed a total of 647½ lbs. and Lot II 648½ lbs. The wethers were all dipped, as they were troubled with ticks when bought. The shed feeding did not start until Nov. 22, so that for seven weeks of the experiment the wethers had free range of pasture or rape. From the beginning of the experiment grain was fed to both lots. They were fed ½ lb. of oats per head daily during the first two weeks and they had the run of a rape field in addition. The grain ration was then changed to 1 part corn and 1 part oats, and this was continued until the experiment closed. Until Nov. 7th the wethers were kept on rape when they were given fresh pasture for two weeks and brought in to the sheds Nov. 22d. They then received clover hay in addition to the grain mixture described.

The wethers were sold without being shorn. The average length of the fleece of the fall shorn wethers measured at the shoulder was about an inch, so that it was almost impossible and certainly inadvisable to shear them at that time. While the lambs that were fall-shorn would be reduced in price somewhat because of the shortness of their fleece, this would be more than compensated for by the 29.4 lbs. of wool they clipped in the fall.

	Lot I. 8 wethers fall shorn	Lot II. 8 wethers unshorn.	Difference in Favor of Fall shorn	Difference in Favor of Un-shorn
	lbs.	lbs.	lbs.	lbs.
Weight Oct. 6th, beginning of experiment	618.1	648.5	.. ..	30.4
Weight Dec. 15th, ending of experiment	812.5	817.5	....	5
Gain in 10 weeks	194 4	169	25.4	....
Average weekly gain per head	3.4	3	.4	....
Total quantity of unwashed wool shorn...........	29.4	....	29.4	....
Hay eaten	292.5	278 5	... .	14
Oats	290.5	265.5	... .	25
Cost of food	$ 5.56	$ 5.08	....	$ .48
Cost of 100 lbs gain omitting pasture..............	$2.86	$3.00	$ .14	....

1. The fall shorn wethers made the greater gain, for during a period of 10 weeks the eight wethers in this lot gained a total of 25.4 lbs. more than the others.

2. The gain of the fall shorn wethers was made at a cheaper rate as the cost of 100 lbs. gain in their instance was $2.86 exclusive of pasturage, while the cost of 100 lbs. gain in the unshorn lot was $3.00.

3. This experiment bears out the position indicated by the preceding trial, that the effect of the removal of the fleece is to hasten the fattening process until such time as the wool has attained a growth of one or two inches.

Dividing the total period of the experiment into two periods of five weeks each we find that the fall shorn wethers gained 18.4 lbs. more than the unshorn during the first five weeks, though they each received exactly the same amount of grain and similar pasturage. During the next five weeks the shorn wethers gained a total of 7 lbs. more than the unshorn, but the shorn wethers ate 50 lbs. more grain and 14 lbs. more hay than the shorn during this time.

GENERAL SUMMARY.

1. Fall shearing is a beneficial practice to prepare lambs that are six months old for the early winter market.

2. To secure the benefits for fall shearing it should be done early in the season, at least not later than October.

3. When done under such circumstances the removal of the fleece hastens the fattening, and the gain is made at a slightly cheaper rate.

4. The results show that by shearing in the fall and again in the spring more wool is obtained than from a single spring shearing, but the market value of the two clippings is not any greater than that of the single clipping in which the fibres of the fleece are longer.

5. When the lambs are to be fattened during three or four of the winter months, there appears to be no practical advantage in fall shearing.

GRAIN FEEDING LAMBS FOR MARKET.*

JOHN A. CRAIG.

The experiments herein described were undertaken for the purpose of comparing the profitableness of the different systems of lamb feeding.

There are three methods of fattening lambs in general practice. In the first method the lambs are fed grain from the time they will begin to eat it until they are put on the market ten or twelve months later. In the second method the lambs do not receive any grain until the fattening begins in the fall when the sheep are put in sheds. In the third method the lambs receive grain from weaning time until they are finished for market.

In those countries where mutton sheep have been bred for many years and the feeding of them has become a subject of special study, the chief problem the shepherd has constantly before him is the provision of such food as will keep the lambs steadily increasing in weight at all seasons from the time of birth until marketed. The tastes of the lambs are studied and the most appetizing rations are fed to them before they are weaned. After weaning, green fodder crops, such as rape, vetches and turnips are freely used to keep the lambs thriving. In the fattening process the aim is to get as rapid gains as possible by frequent and careful feeding of a variety of fattening foods.

A strong contrast to this is offered by the method in general practice on many farms. Before weaning the lambs receive no grain and they get no nearer to it after

*Reprinted from Bulletin No. 41 of this Station.

weaning than to have the range of corn or grain field after harvest. Fattening begins and ends with feeding corn in many instances, though there are home-grown grains that could be profitably marketed in this way. It is considered by those who adopt this practice that by denying the lambs any grain before or after weaning much greater gains can be obtained from them when the fattening is commenced.

Midway between these systems is that followed by many which has for its distinctive feature the feeding of grain to the lambs from the time of weaning until they are marketed. The effect of this management is to carry the lambs over the weaning period without any material check being given to their growth. To that extent it is a better system than the other, which allows the lambs no grain until the winter feeding begins.

Such being the practices that are usually followed, it was considered to be a practical line of experiment to study the differences in the effects of these methods and the profits from them under our conditions.

THE SCOPE OF THE EXPERIMENTS.

The experiments have extended over the years 1891, 1892 and 1893. They began each year as soon as the lambs were old enough to be used; in April or May they would begin to eat, and from those months the work was continued until the lambs were marketed the following February. This time was divided into three periods, the first being included in the time preceding weaning, the second after weaning, and the third fattening in the sheds during winter.

In the first and second experiments there were only two lots of lambs, the one lot receiving grain over all the periods and the other lot not receiving grain until the fattening period. In the third experiment a third lot was introduced and this lot received grain from the time they were weaned. In all particulars the lambs received the same management. After weaning they all had similar pasture

and when put in the same shed to fatten they were fed a ration consisting of similar foods. The only variation in the feeding consisted in the grain feeding followed in the instance of some of the lots before and after weaning, and that formed the basis of the experiments.

In all the trials the ewes in each trial and in each lot received the same management and food. In no instance were they given grain. Their food was chiefly pasture, with some fodder during the time that the pasture was not accessible. The ewes of all lots and in all trials were weighed weekly during the time previous to weaning, but there was not sufficient difference in their weights or food to influence the results in any respect.

I. Statement of Data in Detail.

THE FIRST TRIAL.

As the first trial in this direction has been described fully in the Ninth Annual Report of this Station it will be unnecessary to describe it here further than to present the leading facts that bear out the assumptions that follow. The trial began in the spring of 1891 and was continued until that of 1892. Two lots of lambs with three in each were used.

FEEDING BEFORE WEANING—IN THE FIRST TRIAL.

The first period includes the time preceding weaning. When this period started the lambs were about three weeks old and when weaned they were three months old. During this time Lot I received a grain mixture of 1 part bran, 1 part cornmeal and ¼ part oilmeal. The following statement shows the progress of the six lambs under these circumstances during the first period:

Table I.—Increase and food of lambs before weaning—1st trial.

	Lot I. Lambs (3) fed grain.	Lot II. Lambs (3) no grain.	Differences in favor of Grain.	Differences in favor of No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, April 30	18.6	19.3	....	.7
Average weight of each lamb at ending, July 9	63.5	55.8	7.7	....
Average gain of each lamb in ten weeks	44.8	36.5	8.3	....
Average weekly gain of each lamb	4.48	3.65	.83	....
Grain eaten per head by Lot I.— Bran 11.8, Cornmeal, 11.8, Oilmeal, 2.9	26.6	....	....	....
Cost of grain for each lamb	18 cts.	....	....	....

FEEDING AFTER WEANING — IN THE FIRST TRIAL.

The lambs were weaned July 9th, when they were about three months old, and from that time until November 9th, they were all given similar pasture; the only difference in the feeding being that Lot I received a grain mixture of two parts ground corn and one part oilmeal. At the beginning of this period two more lambs were added to each lot. They were lambs that had been previously managed similar to those in the lots to which they were added. Lot II by this means received an increase of 21.5 lbs. that was not produced by it. The following table will show the progress of the lambs during this period:

Table II.—Increase and food of lambs after weaning—1st trial.

	LOT I. Lambs (5) fed grain.	LOT II. Lambs (5) no grain.	DIFFERENCES IN FAVOR OF Grain.	DIFFERENCES IN FAVOR OF No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning	53	52 7	.3	....
Average weight of each lamb at ending, November 19	103.7	82.6	21.1	....
Average gain of each lamb in 19 weeks	50.7	29.9	20.8	....
Average weekly gain of each lamb	2.66	1.86	.8	....
Grain eaten per head by Lot I.—				
Ground corn 122 / Oilmeal 61	183	....	....	....
Cost of grain for each lamb	$1.47	....	....	....

FEEDING DURING FATTENING—IN THE FIRST TRIAL.

This period began November 19th, and extended to February 25th, an interval of 14 weeks. The lambs were fed similar foods and given the same management in all respects. Their rations consisted of corn fodder and roots with as much grain as they would eat, consisting of a mixture of 2 parts whole oats, 1 part whole corn and 1 part oilmeal. The appended table will indicate the effect of the previous management on the fattening:

Table III.—Increase and feed of lambs during fattening period—1st. trial.

	LOT I. Lambs (4) grain previously.	LOT II. Lambs (4) no grain previously.	DIFFERENCES IN FAVOR OF	
			Grain.	No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, November 19....	106.3	84.3	22	....
Average weight of each lamb at ending, February 25..........................	145.7	125.7	20	....
Average gain of each lamb in 14 weeks...	39.4	41.4	....	2
Average weekly gain of each lamb........	2.81	2.95	....	.14
Average weight of fleece	10.1	7.0	3.1	....
Food eaten by each lamb—				
Oats.......	66.8	68.5	1.7	....
Corn	33.4	34.2	.8	....
Oilmeal:.......................	33.4	34 2	.8	....
Corn fodder..........	190.3	172.1	....	18.2
Roots	89.2	89.2	... .	....
Cost of food for each lamb.......	$1.62	$1.62	....	....

THE SECOND TRIAL.

In the second trial, undertaken in the spring of 1892, there were ten ewes and 14 lambs in each lot in the period before weaning, and from these five lambs were selected and with them the experiment was continued and concluded. In Lot I the lambs were fed all the grain they would eat, and those in Lot II were not given any grain.

FEEDING BEFORE WEANING—IN THE SECOND TRIAL.

The time covered by this period extends from April 27th to July 20th, an interval of twelve weeks, during which the lambs in Lot I were first fed a mixture of 3 parts bran and 1 part oilmeal for three weeks and then 1 part oilmeal, 1 part gound corn and 2 parts bran the succeeding nine weeks. Those in Lot II did not receive any grain. The results are shown in the appended statement:

Table IV.—Increase and food of lambs before weaning—2d trial.

	Lot I. Lambs (14) fed grain.	Lot II. Lambs (14) no grain.	Differences in favor of Grain.	Differences in favor of No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, April 27	24.2	22.7	1.5	....
Average weight of each lamb at ending, July 20	61.8	56.2	5.6	....
Average gain of each lamb in 12 weeks	37.6	33.5	4.1	....
Average weekly gain of each lamb	3.1	2.7	.4	....
Grain eaten per head by Lot I.— Oilmeal 10.6, Ground corn 8.8, Bran 23.3	42.7	....	....	....
Cost of grain for each lamb	34 cts.	....	....	....

FEEDING AFTER WEANING—IN THE SECOND TRIAL.

From the fourteen lambs that were in each lot before the time of weaning, five lambs that represented the average of the fourteen, were selected from each lot, and with these the experiment was continued. During the first week after weaning the grain food, bran, oilmeal and ground corn, was continued to Lot I, but after that time they received whole oats, while Lot II did not receive any grain. Both were allowed similar pasture.

Table V.—Increase and food of lambs after weaning—2d trial.

	Lot I. Lambs (5) grain.	Lot II. Lambs (5) no grain.	Differences in favor of Grain.	Differences in favor of No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning July 20	65.8	58.2	7.6	....
Average weight of each lamb at ending, Nov. 9	99.8	84.5	15.3	....
Average gain of each lamb in 16 weeks	34.0	26.3	7.7	....
Average weekly gain of each lamb	2.1	1.6	.5	....
Grain eaten per head by Lot I— Oats 120.5, Bran, oilmeal, corn 6.9	127.4	....	....	....
Cost of grain	$1.13	....	....	....

FEEDING DURING FATTENING—IN THE SECOND TRIAL.

The third period in the management of these lambs began on November 9th and was continued until February 15th, thus extending over fourteen weeks. The lambs in the experiment during the former period was retained. At the beginning of the period the lambs received oats, roots and corn fodder. The grain was increased later by the addition of corn and towards the end of the period some oilmeal was fed and the corn fodder changed to hay.

Table VI.—Increase and food of lambs during fattening—2nd trial.

	LOT I. Lambs (5) grain previously.	LOT II. Lambs (5) no gain previously.	DIFFERENCES IN FAVOR OF	
			Grain.	No grain.
	lbs.	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, Nov. 9...	99.8	84.5	15.3	....
Average weight of each lamb at ending, Feb. 15.......	140.3	125.5	14.8	....
Average gain of each lamb in 14 weeks....	40.5	41	....	.5
Average weekly gain of each lamb........	2.8	2.9	....	.1
Average weight of fleece..................	8.8	7.8	1	....
Food eaten per head:				
Oats	120	114.3	....	5.7
Corn	42	40.5	....	1.5
Oilmeal................................	39.5	38.1	....	.95
Corn fodder............................	45.6	40.6	....	5
Roots	103.8	90.8	....	13
Hay	97.2	104.2	7	....
Cost of food for each lamb................	$2.35	$2.30	....	$.05

THE THIRD TRIAL.

This trial was started May 10th, 1894, and continued until the last day of January, 1894. Twelve ewes and their fifteen lambs were taken and divided into three lots with four ewes and their five lambs in each. The lambs in Lot

I were fed grain throughout all the periods, those in Lot II received grain only during the fattening period and those in Lot III were given grain from the time they were weaned until fattened for market.

FEEDING BEFORE WEANING—IN THE THIRD TRIAL.

The lambs in the grain fed lot were given a mixture of 1 part bran and 1 part oilmeal. They were mostly Shropshire grades, averaging about six weeks old when the experiment started. The following statement shows the conduct of the lambs in the first period, including the time before weaning:

Table VII.—Increase and food of lambs before weaning—3rd trial.

	LOT I. lambs (5) grain.	LOT II. lambs (5) no grain.	LOT III. lambs (5) no grain.
	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, May 10...	37.3	36.9	37
Average weight of each lamb at ending, Aug. 2.	78.2	65.1	70.6
Average gain of each lamb in 12 weeks...............	40.9	28.2	33.6
Average weekly gain of each lamb.....................	3.40	2.35	2.80
Grain eaten per head by Lot I.— Bran. ......25, Oilmeal......25	50	....	....
Cost of food for each lamb............................	47 cts.	....	....

FEEDING AFTER WEANING—IN THE THIRD TRIAL.

The second period was started August 2d, when the lambs in all the lots were weaned. They had like pasturage. The lambs in Lot I were fed oats, those in Lot II did not receive any grain, and those in Lot III also received oats. The same lambs that were used in the previous period were retained.

Table VIII.—Increase and food of lambs after weaning—3rd trial.

	LOT I. Lambs (5) grain.	LOT II. Lambs (5) no grain.	LOT III. Lambs (5) grain since weaning.
	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, August 2..	78.2	65.1	70.6
Average weight of each lamb at ending, November 8..	97.6	77.9	91.7
Average gain in 14 weeks.	19.4	12.8	21.6
Average weekly gain	1.4	.91	1.5
Food eaten per head, oats	62.1	....	62.1
Cost of grain per head	56 cts.	....	56 cts.

FEEDING DURING FATTENING — IN THE THIRD TRIAL.

The third or fattening period in this trial began November 8, when the wethers in the three lots were put on the same rations. The grain mixture fed to each lot during the greater part of the fattening period consisted of one-half oats and one-half corn. In addition to this mixed hay was fed. All the lots were given as much as they would eat of the hay and the grain mixture

Table IX.—Increase and food of lambs during the fattening—3rd trial.

	LOT I. Lambs (5) grain.	LOT II. Lambs (5) no grain previously.	LOT III. Lambs (5) grain since weaning.
	lbs.	lbs.	lbs.
Average weight of each lamb at beginning, Nov. 8	97.6	77.9	91.7
Average weight of each lamb at ending, Jan. 31	134.6	113.9	124.6
Average gain of each lamb in 12 weeks	37	36	32.9
Average weekly gain of each lamb	3.08	3	2.74
Average weight of fleece	8.3	5.7	7.1
Food eaten –			
Corn	106.8	92.6	105.5
Oats	75.1	66.1	73.4
Hay	91	89.5	83.6
Cost of food	$1.79	$1.60	$1.74

II.—Bearing of the Results on Special Features.

To study the influence of these facts on special points it will be necessary to give fuller details in regard to the data bearing on them. In this way it will be advisable to discuss the profitableness of the practices and also present the results obtained in reference to the effect upon the carcass and the wool.

IT PAYS TO FEED GRAIN BEFORE AND AFTER WEANING.

Before discussing this feature it is necessary to emphasize that the grains which are fed to the lambs both before and after weaning were more favorable to growth than to fattening. Neither was it the aim to feed them in such quantities as to hasten the fattening at the expense of the growth. This may in a large degree account for the evenness of the progress of the lambs during the fattening period. The foods that were most fed during these periods were bran, oats and oilmeal.

The chief condition that makes it profitable to feed grain is the advanced price per pound which well fatted lambs will bring over those that are only in fair condition as to flesh. In these trials the value of the lambs represents their estimated value in the judgment of a local butcher, and the prices used in determining the value of the lambs at the end of the last period are those that they brought in our local market. The other prices are based on those of the Chicago market to a large degree. The lambs that were fed grain continuously were estimated by the butcher to be worth ¼ cent per lb. more at weaning time, 1 cent more in the fall and ¾ cent more when sold in the spring than those that had no grain before and after weaning. The lambs that had grain from the time of weaning were thought by the butcher to be worth ½ cent more per lb. when sold in the spring than those that had not received any grain previous to fattening.

Table X.—Summary of the three trials

	LOT I. GRAIN SINCE BIRTH.				LOT II. NO GRAIN PREVIOUS TO FATTENING PERIOD.				LOT III. NO GRAIN PREVIOUS TO WEANING.			
	Average weekly gain per head.	Gain per head during each period.	Extra cost of gain per head during each period.	Average weight and value per head at end of each period.	Average weekly gain per head.	Gain per head during each period.	Extra cost of gain per head during each period.	Average weight and value per head at end of each period.	Average weekly gain per head.	Gain per head during each period.	Extra cost of gain per head during each period.	Average weight and value per head at end of each period.
FIRST TRIAL, 1891-92.	Lbs.	Lbs.	$		Lbs.	Lbs.	$		Lbs.	Lbs.	$	
1st Period: 10 weeks, April 30 to July 9.	4.48	44.8	.18	63.5 lbs. @ $5.66=$3.59	3.65	36.5	......	55.8 lbs. @ $4.91=$2.73	......	......	......	......
2d Period: 19 weeks, July 9 to November 19	2.66	50.7	1.47	103.7 lbs. @ 4.81= 4.98	1.86	29.9	......	82.6 lbs. @ 3.81= 3.14	......	......	......	......
3d Period: 14 weeks, November 19 to February 25	2.81	39.4	1.62	145.7 lbs. @ 6.35= 9.25	2.95	41.4	1.62	125.7 lbs. @ 5.60= 7.03	......	......	......	......
SECOND TRIAL, 1892-93.												
1st Period: 12 weeks, April 27 to July 20	3.1	37.6	.34	61.8 lbs. @ $5.66=$3.49	2.7	33.5	......	56.2 lbs. @ $4.91=$2.75	......	......	......	......
2d Period: 16 weeks, July 20 to November 9	2.1	34.	1.13	99.8 lbs. @ 4.81= 4.80	1.6	26.3	......	84.5 lbs. @ 3.81= 3.21	......	......	......	......
3d Period: 14 weeks, November 9 to February 15th	2.8	40.5	2.35	140.3 lbs. @ 6.35= 8.90	2.9	41.	2.30	125.5 lbs. @ 5.60= 7.03	......	......	......	......
THIRD TRIAL, 1893-94.												
1st Period: 12 weeks, May 10 to August 2	3.4	40.9	.47	78.2 lbs. @ $5.66=$4.42	2.35	28.2	......	65.1 lbs. @ $4.91=$3.19	2.8	33.6	......	70.6 lbs @ $4.91=$3.46
2d Period: 14 weeks, August 2 to November 8	1.4	19.4	.56	97.6 lbs. @ 4.81= 4.69	.91	12.8	......	77.9 lbs. @ 3.81= 2.96	1.5	21.1	.56	91.7 lbs. @ 4.00= 3.66
3d Period: 12 weeks, November 8 to January 31	3.08	37	1.79	134.6 lbs. @ 4.25= 5.72	3	36	1.60	113.9 lbs. @ 3.50= 3.98	2.7	32.9	1.74	124.6 lbs. @ 4.00= 4.98

The appended table is a summary of all the trials with the principal data that bear on the profitableness of these practices brought forward. The value of the lambs in each lot and the comparative cost of each are easily seen. It may be again noted that the first period includes the time preceding weaning, the second period after weaning until fattening and the third, the fattening period.

There is no question but that if the lambs were to be sold immediately after weaning or late in the fall without carrying them over winter, it would pay to feed grain. The gain in the lambs and their increased value per pound would be the chief arguments for this. The most important matter to be determined, then, is whether it pays to feed grain previous to the usual time of fattening in instances where the lambs are not sold until late winter or early spring.

THE RELATIVE PROFIT FROM FATTENING.

In the first trial if we charge the grain-fed lambs in Lot I with the cost of the grain food they ate before and after weaning. and also that of the fodders and grains they ate during fattening it will amount to $3.27. At their valuation per pound at that time they were worth $9.25 per head, thus leaving $5.98 as the comparative profit per head. The cost of food for the lambs in Lot II that did not receive any grain until fattening amounted to $1.62 per head, and their market value was $7.03, leaving a comparative profit of $5.41. In this way the grain-fed lambs gave a return of 57 cents per head more than the others. In these estimates the cost of pasturage has not been included, but it would not affect the position of the lambs, as they all had similar pasturage.

In the second trial. as the table shows, the cost of the grain fed the lambs in Lot I before and after weaning and the ration during fattening amounted to $3.82, and their market value $8.90 per head, leaving a balance of $5.08. The lambs in Lot II ate $2.30 worth of food per head during fattening, and their market value was $7.02, leaving a

balance of $4.72. The difference in the profit per head amounts to 36 cents in favor of the grain-fed lambs.

In the third trial the cost of the food consumed by the grain-fed lambs during all periods was $2.82, and the estimated value at the low price per pound then current was $5.72, leaving a balance of $2.90, as against a similar balance of $2.38 from the lambs in Lot II that had no grain until fattening, and a balance of $2.68 from the lambs in Lot III that had grain since weaning time.

From these figures it will be seen that the profit from lambs that had grain during the three periods was 48 1-3 cents per head greater than those that had no grain until the fattening began in the fall. And it is further shown that the lambs that were fed grain from the time of weaning also yielded a greater profit per head than those not receiving grain until fattening. It remains to be said in considering this feature that the grains that were fed have been charged to the lambs at the market prices prevailing in Wisconsin over a term of years. In these estimates no consideration has been given to the cost of pasturage and care, so that the term "comparative profit" is used for the purpose of comparing the profit of the lots with those items omitted.

EARLIER MATURITY AND EARLIER MARKETING OF THE GRAIN-FED LAMBS.

The length of time it took under these different systems of feeding to bring the lambs in each of the lots to similar weights has a practical bearing that calls for inquiry. In the first trial, when the trial ended February 25th, the lambs in Lot II that had not received any grain before the fattening period averaged 125.7 lbs. The lambs in Lot I that had grain during all the periods averaged in live weight 125.2 lbs. on December 31st, about seven weeks before the others. The food, omitting pasturage, to get the latter up to that weight cost $2.25, while that required by the lot that had no grain was only $1.62. The difference in the cost originated in the heavy grain feed-

ing after weaning to Lot I. They ate about 1⅛ lbs. of grain per day on pasture during that time.

In the second trial the lambs in Lot II that had no grain before or after weaning weighed an average of 125.5 lbs. when the experiment was closed February 15. The grain fed lambs in Lot I averaged 124.6 lbs. January 18th, so that the grain fed lambs were about one month ahead of the others. To make the lambs in Lot II weigh 125.5 lbs. it cost in food $2.30, while in the instance of those of Lot I it cost $3.12. The difference here was likely due to the same cause as in the first trial, the high grain feeding after weaning, as the lambs so fed received 1.1 of grain per head per day when on pasture.

From the experience gained from the two previous trials, and knowing that the high cost of the grain fed lambs in comparison with the others was due to the heavy feeding from the time of weaning, the quantity of grain fed during that period was greatly reduced, the lambs getting only about one-half pound per head daily. The lambs that had not received any grain previous to fattening weighed an average of 113.9 lbs., on January 31 when the experiment was concluded. Those in Lot III, fed grain since weaning weighed an average of 111.2 lbs. January 3rd, while the lambs that had grain given them through all the periods weighed 112.7 lbs. December 12th. They were seven weeks in advance of those that had not received grain. To bring the lambs in Lot II to that weight cost $1.79, those of Lot III $1.63, and those of Lot I $1.60. The grain fed lambs then not only matured much earlier but the cost of gain was also less. Considering the greater amount of labor to feed the lambs that had no grain previous to fattening over the longer time, including the risk of loss and the advanced value of the grain-fed lambs per pound it certainly shows that there was a gain from this management.

The chart on the next page shows the difference in the progress of the lots in these respects. Through this arrangement it is easy to compare the weights of the lambs at any time during the course of the trials.

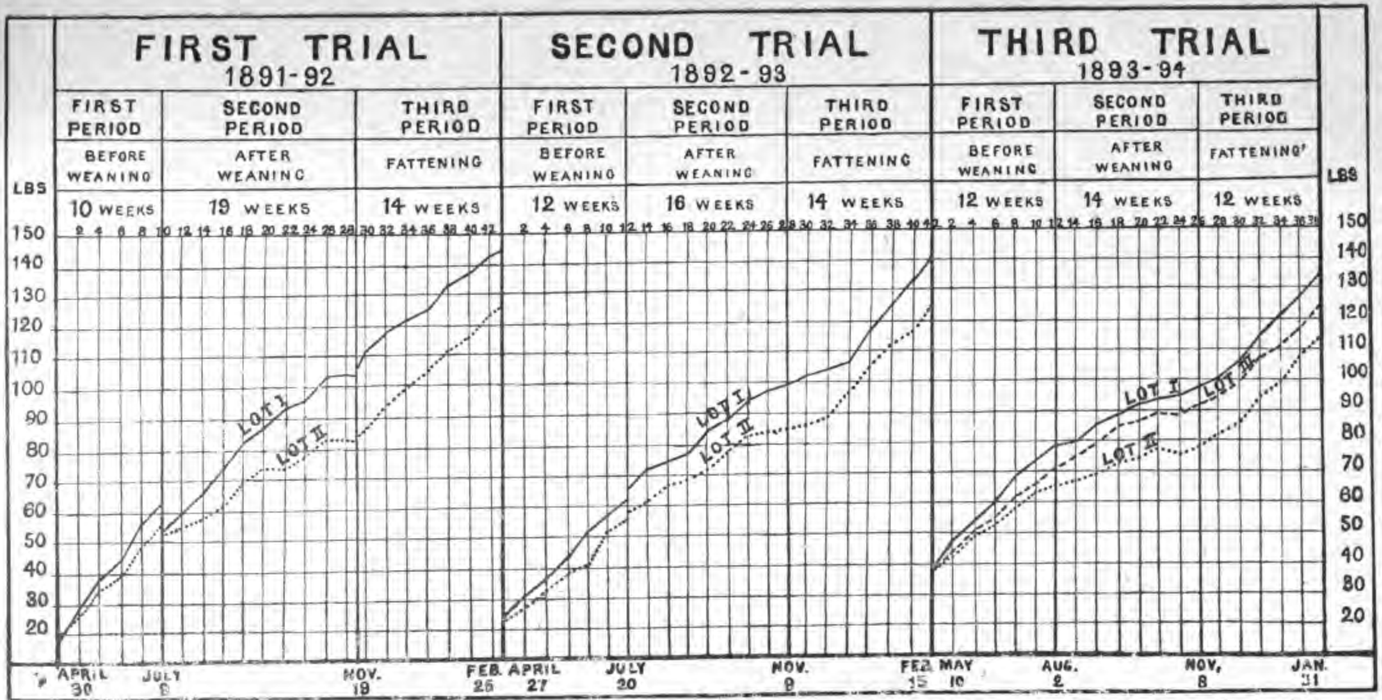


FIG. 12.—Chart illustrating the result of three trials in grain feeding lambs. The horizontal lines mark the increase in each ten pounds of weight: the peredndicular lines divide the time over which the experiment extended into intervals of two weeks. The unbroken line shows the average gain in weight of the lambs in Lot I that were fed grain over all periods, or since birth. The dotted line shows the average gain in weighs of the lambs in Lot II that were not fed grain until the third or fattening period. The broken line shows the average gain in weight of the lambs in Lot III that were fed grain from the time of weaning, or during the periods after weaning and fattening.

FIG. 13.—Wether representing those in Lot II in the second trial at the beginning of the third or fattening period. The wether shown in the accompanying illustration then weighed 82 lbs., and the average weight of those in Lot II at that time was 88.8 lbs. The effect of not having received any grain up to Nov. 9th is observable in the open, staring fleece, the smaller size and the rougher form of this wether in comparison with the one shown in the next figure which was taken at the same time.

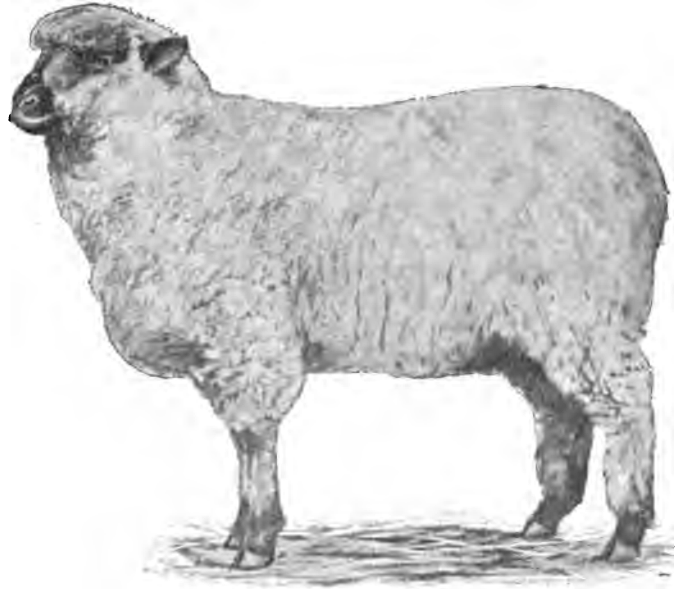


FIG. 14.—Wether representing those in Lot I in the second trial at the beginning of the third or fattening period. This wether then weighed 106 lbs., and the average weight of lot I at that time was 104.3 lbs. The effects of the grain feeding from birth is apparent in the greater growth, the denser and smoother fleece and plumper appearanne of this wether in comparison with the one shown in the preceding figure.

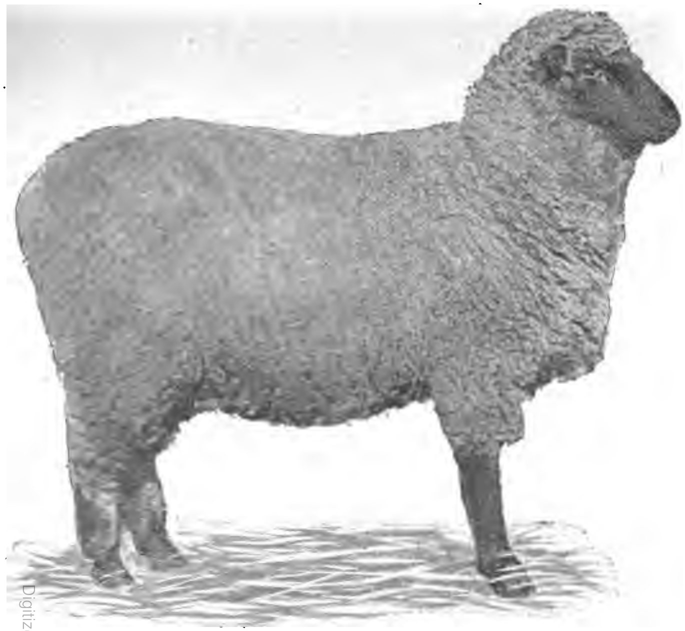


FIG. 15.—Wether representing those in Lot III in the third trial at the end of the third period when they were ready for market Jan. 31st. This wether then weighed 124 lbs., and the average weight of Lot III at that time was 124.6 lbs. No grain was fed to the wethers in this lot, until the lambs in it were weaned. Comparing it with the wether in Fig. 16 that was taken at the same time but had grain since birth, the wether appearing above shows a more open fleece, a checked growth and it lacks finish.

FIG 16.—Wether representing those in Lot I in the third trial at the end of the third period when they were finished for market. The wether appearing in the above illustration then weighed 140 lbs., and the average weight of those in Lot I at that time was 134.6 lbs. This wether had been fed grain continuously since birth and should be compared with the one shown in Fig. 15. This wether will be noticed to be larger, smoother in fleece and in a better conditian for market.

EFFECTS ON THE INCREASE IN WEIGHT.

By following the lines in the chart illustrating the progress of the lambs in the different lots it is evident that the chief difference in their increase originated after weaning. It should be here stated that the break in the lines is due to the changes that had to be made in the lots. From the time of weaning until the beginning of the fattening, the difference in the weights of the lambs in the respective lots increased. This is not so evident before weaning, owing to the shorter time and the smaller quantity of grain eaten by the lambs receiving it.

Comparing the quantity of grain it required to make one pound of gain before weaning with that required afterwards we find that it required less before weaning. Such a comparison necessitates the offsetting of the milk which the lambs received from the ewes before weaning against the pastures which they received after weaning. Before weaning in the first trial it took .59 or about one-half pound of grain to make a pound of gain; in the second trial the grain-fed lambs made a pound of gain on 1.1 lbs. of grain, and in the third trial they made it on 1.2 lbs. of grain.

After weaning when the lambs were on pasture it took 3.6 lbs. of grain to make a pound of gain in the first trial; in the second trial it took 3.6 lbs. grain for a pound of gain and in the third trial the lambs that had received grain from birth made a gain of one pound for 3.2 lbs. of grain, while those in the other lot receiving grain after weaning made a pound of gain for each 2.9 lbs. of grain in the interval between weaning and fattening.

These facts make it evident that it paid best to feed the grain before weaning, though it is not fair to assume that ewes' milk is only equal to good pasture, as has been done in this comparison.

INFLUENCE ON THE CHARACTER OF THE MEAT.

In the second and third trials the lambs were slaughtered, the carcass cut back of the fifth rib and an examination made of the mixture of fat and lean. In both instances there was no apparent difference in the lots in that respect. This was to be expected from the fact that the lambs previous to fattening had received such foods as bran, oats and some oilmeal, which are favorable to growth, while during the fattening process they received similar rations. The flesh in nearly all instances was evenly mixed, and in none were the carcases heavily loaded with fat.

The dressed weights of the different lots in the second and third trials were also obtained. The lambs were fasted over three meals, and the weighing of the carcasses was done after they had become sufficiently rigid to permit the weighing to be done.

The grain-fed lambs in the second trial dressed 56.6 per cent., and those that had no grain before fattening dressed 55.7 per cent. In the third trial the grain-fed lambs dressed 52.3 per cent.; those in Lot II that had no grain before the fattening period dressed 52.8 per cent., and those that had grain since weaning dressed 52.2 per cent. So that it may be said that there was no appreciable difference in the per cent. that the lambs in each lot dressed. The weights of the blood, heart, lungs, kidneys, pelt, caul fat and kidney fat was taken in the instance of fifteen lambs in all the lots and no marked or uniform differences were found between the lots in these respects.

EFFECT OF GRAIN FEEDING ON THE WOOL.

At all times during the three trials it was an easy matter to select by the eye the lambs that received grain before and after weaning. The fleeces of these were dense and smooth in appearance, while those of the lambs that had no grain were always open and rough. The smoothness of the fleeces of the grain-fed lambs may be attributed to

the greater density of wool and also the greater amount of yolk or oil that was found to be in their fleeces.

The quantity of wool shown from the different lots under these various systems of management was decidedly favorable to grain feeding. In the first trial the lambs that had grain since birth sheared an average of 10.1 lbs. unwashed wool when the experiment was concluded, and those that did not receive any grain until fattening sheared an average of 7 lbs. per head. In the second trial the lambs receiving grain continuously sheared an average of 8.8 lbs. per head, and the lambs that did not have any grain until fall sheared an average of 7.8 lbs. per head. In the third trial the lambs that received grain from birth sheared an average of 8.3 lbs. wool per head, those that had grain from weaning sheared an average of 7.1 lbs. per head, and those not receiving grain until fattening sheared an average of 5.7 lbs. per head. Taking the average of the three trials, the lambs receiving grain from birth averaged 9 lbs. unwashed wool per head, those receiving it from weaning time averaged 7.1 lbs. and those not receiving any until winter feeding started averaged 6.8 lbs. per head.

DIFFERENCES IN FLEECE WEIGHTS CHIEFLY DUE TO YOLK.

The greater amount of yolk that was found in the fleeces of the lambs fed grain continuously to some degree accounts for the greater weight of their fleeces.

In the first trial on the conclusion of the experiment one pound of the wool from each of the sheep was washed in water at a temperature of 100 degrees, Fahr.

The wool from the lambs that had grain from birth shrank 41.2 per cent. while those not receiving grain until fattening lost 36.2 per cent. In the second trial one pound samples were washed in water at a temperature of 120 degrees, Fahr. The shrinkage of the wools of the grain-fed lambs was 48 per cent. and that of the lambs in the lot not fed grain was 43 per cent. In the third trial half pound samples were washed in water at a temperature of 130 degrees, Fahr., and it was found that the wool of the lambs

fed grain continuously lost 38 per cent., that from the lambs fed grain from weaning 36 per cent. and that from the lambs given no grain until fattening lost 36 per cent. in washing. These differences in the shrinkage in the washing may be credited to the removal of the yolk, or natural oil in the wool. The results of the three trials show that the average yield per head of wool washed as described has been 4.6 lbs. from the lambs receiving grain from birth, and 4.1 lbs. per head from those that had no grain until the fattening began.

LONGEST WOOL FIBRES FROM GRAIN FEEDING.

The length of the wool fibre seems to have been slightly influenced by the grain feeding and small measure contributed to the weight of the fleeces of the lambs so fed. The shoulder wool was measured without disturbing the crimp and in the first trial it was found that the average length of the fibre of the grain fed lambs was five inches, while in the instance of the lambs that had no grain before fattening the average length was 3.76. In the second trial the increase clip of wool obtained from the grain fed lambs was due altogether to the yolk it contained for the average length of the fibre of the lambs was 4 inches and that of those that had not received grain before fattening began was 4.2 inches; a difference so slight as to be within the range of error. It should be noted that the difference in the weights of the fleeces between the two lots in this trial was the smallest of any of the trials. In the third trial the fibre in the instance of those that had grain from the time of weaning it was 2.8 inches, while the lambs fed grain continuously averaged 3.3 inches long, and in the instance of that of the lambs that had no grain before or after weaning it was 2.9 inches. The average of the three trials shows that the average length of the wool fibre from the lambs fed grain continuously was 4.5 inches, while that from the lambs that did not receive grain previous to shed feeding was 3.7 inches.

GENERAL BEARING OF THE RESULTS ON FEEDING LAMBS.

The most important fact bearing on farm practice that is brought forward by the data of these trials is that it pays to feed lambs grain from the time of birth until they are marketed. It is reasonable to infer that the kind of grain fed before and after weaning had an influence on the results. Of the grains that have been tried before weaning we have found bran the best for lambs at that age. Ground oats are good, but their hulls are left almost untouched. A small quantity of oilmeal, $\frac{1}{4}$ by weight, mixed with the bran makes an excellent mixture. The lambs will begin to eat between the ages of two and three weeks if they have a part of the pen partitioned off as a feeding apartment for them. A lamb creep can be easily arranged by nailing slats to two cross pieces far enough apart for the lambs to pass through but too narrow for the ewes. About the fourth week the lambs will be eating from $\frac{1}{4}$ of a pound daily and by the time weaning approaches they should be getting $\frac{1}{2}$ lb. per head daily. After weaning oats makes an excellent ration. They do not need to be ground. At this time until fattening starts it will be found the most profitable to limit the lambs to half a pound of oats per head daily.

When the fattening begins the oats may be added to by the addition of corn. Best results have been obtained by feeding equal mixture by weight of oats and corn for the first month and then increasing the proportion of corn to hree parts by weight and continuing to feed that the following month, and then finish the fattening by the addition of a small quantity of oil meal, about $\frac{1}{4}$ by weight. The lambs may be started on one pound per head daily, and increased so that the average daily ration throughout the fattening will be about two pounds per head. As soon as the lambs have started well it is a safe guide to feed them all they will eat with a relish. The ration should be added to by the addition of two or three pounds of clover hay or corn fodder and the same amount of roots.

III.—Summary of Results.

The following condensed results have been obtained from feeding lambs in this way in comparison with the other method which allows them no grain before weaning or until fattening begins in the fall:

1. The feeding grain before weaning produced an average of 61 cts. per head more profit at weaning time than that obtained from the lambs receiving no grain. The average value of each lamb in the lot receiving grain at $5.66 per hundred was $3.83 per head, and the average value of the grain they ate was 33 cts. per head, while the average value of the other lot not receiving grain at $4.91 per hundred lbs. was $2.89, leaving 61 cts. profit per head in favor of grain feeding. The average of the three trials shows that the grain-fed lambs before weaning required 4 lbs. of grain for each 1 lb. of gain that they made over the lambs that had no grain.

2. The feeding of grain after weaning to lambs that had not received any before weaning produced an average increase which slightly more than paid a good market price for the grain they ate up to the time they were to be sold in the fall. The average value of each lamb in the fall after having received grain from weaning time was $3.66 at $4.00 per hundred lbs., and they ate 54 cts. worth of grain per head, while the average value per head of those that had not received grain, at $3.81 per hundred lbs., was $2.96; a difference of 16 cts. in favor of the lambs fed grain since weaning. As the average of the three trials it required 6.7 lbs. of grain for the grain-fed lambs to make 1 lb. of gain more than those that had no grain.

3. The feeding of grain both before and after weaning produced an average of 34 cts. per head more profit if sold in the fall than that obtained from the lambs that were not fed grain. The average value in the fall of each lamb in the lots receiving grain before and after weaning, at $4.81 per hundred, was $4.82, and the average cost of grain was $1.38, while at the same time those that had no grain, at

$3.81 per hundred lbs. were worth an average of $3.10 per head, a difference in profit of 34 cts. per head to the credit of the lambs that received grain.

4. The results of the three trials show that there is no appreciable difference in the gain made during the winter fattening between the lambs that had grain previous to fattening and those that had not. The difference in the cost of gain was more marked, there being an average difference of 29 cts. per hundred in favor of those that had no grain previous to fattening.

The average weekly gain per head of the lambs fed grain previously was 2.89 lbs. during the fattening, while that of the other lambs was 2.95. The average cost of one hundred pounds of gain was $4.93 in the instance of the grain-fed lambs, and $4.66 with those that had no grain before fattening started.

5. When the experiment was concluded and the lambs that had grain before fattening and those that had not, were ready for market, the average profit from the former was 48 1-3 cents per head greater than from the latter. The average weight of the grain-fed lambs when sold was 140.2 lbs., and that of the others was 121.7 lbs. per head. The former brought 75 cents per one hundred lbs. more than those that had no grain before winter feeding.

6. The grain-feeding had a marked influence on the earliness of the maturity of the lambs. In the first two trials the grain-fed lambs reached an average of 125 lbs per head in weight, seven and four weeks respectively, before the others. In these trials the average cost of this weight in the instance of the grain-fed lambs was $2.68 per head exclusive of pasture, while in the instance of the other lambs it was $1.96 per head. This difference in cost was largely due to the heavy feeding of grain after weaning, and when this was guarded against in the third trial it was found that the average of 113.9 lbs. per head, which the lambs that had no grain reached on the conclusion of the experiment, was made seven weeks sooner by the lambs fed grain continuously, and it was made at a slightly less cost.

7. There was no difference in the character of the meat in the carcasses of the lambs that had grain continuously and those that had not.

8. The per cent. that the lambs dressed was about the same in all lots, and no marked difference was found in the weight of the different organs of the body.

9. The feeding of grain made all the fleeces of the lambs receiving more compact and smoother than the others.

10. The grain-fed lambs sheared in the three trials an average of 2.2 lbs. wool more per head than the others.

11. The greater amount of wool shorn by the grain-fed lambs was to an extent due to the greater amount of yolk or oil it contained. The shrinkage in the first two trials was 5 per cent. greater in the instance of the grain-fed lambs than with the others, and in the last trial it was 2 per cent. greater.

12. The wool on the lambs that were fed grain continuously grew to a slightly greater length than it did in the fleeces of the others. In the first trial the average length of the shoulder fibre of the grain-fed lot was 5 inches as against 3.76 in the other; in the second trial 4 inches as against 4.2 inches, and in the third it was 3.3 inches against 2.9 inches. The second trial showed no appreciable difference in this particular.

ONE HUNDRED AMERICAN RATIONS FOR DAIRY COWS.

F. W. WOLL.

An investigation of the system of feeding dairy cows practiced by successful Wisconsin farmers was made in the spring of 1892 and described in our Ninth Report. As the results obtained proved of considerable importance and practical value, the investigation was continued on a broader scale during 1893, and in the early part of the year circular letters were sent to more than four hundred dairy farmers and breeders of dairy stock in all parts of the United States and Canada, asking for information concerning their methods of feeding milch cows. The present article is the outcome of these inquiries and contains in a condensed form the main facts brought out bearing on the subject under investigation. One hundred of the farmers to whom the circulars were sent furnished complete rations containing definite quantities of the feed stuffs fed daily to their cows, as exactly as the circumstances would permit. A majority of the rations were not obtained until after considerable correspondence, as many as three letters having in many instances been sent to one party before all the necessary data could be secured. In a large majority of cases it proved impossible to ascertain with reasonable accuracy the quantities of feeding stuffs fed daily, especially as regards the coarse feeds, and many rations which lacked but little of being complete could therefore not be included here.

The writer takes this opportunity of thanking the many parties who favored him with the information asked, for the consideration and public spirit shown in furnishing

data which in many instances was not obtained until after a good deal of trouble and painstaking work. It is hoped that the very varied conditions of feeding represented in the rations reported from the different regions in our large country will suit the cases of one and all American dairymen striving to improve their system of feeding so as to produce the largest quantity of dairy products at the least relative cost of food.

The rations are arranged alphabetically according to states; the names and addresses of the dairymen and breeders who furnished the complete rations fed to their cows are given (by special permission), and then the number of cows in milk in each herd, the breed, average live weight of cows, average annual yield of milk and butter per head, average per cent. of fat in the herd milk, the specialty of farming followed, whether breeding or production of milk, cream, butter or beef, and finally, the length of time and the season during which the cows go dry.

It may be in order to state in regard to the annual yields of butter and milk given that the reports are apt to be rather high in many cases. While some of the figures given are unquestionably correct, the farmers furnishing them keeping careful accounts and knowing exactly just what their cows are doing, others are more of good guesses than anything else—and in such cases, according to human nature, rather too high than the other way. No theories stand or fall with these data, however. If a farmer reports an annual yield of 6,000 lbs. of milk, or of 300 lbs. of butter, we may feel certain that he is doing well and that his figures are approximately correct, if the other information given, his method of feeding, the kind of cows kept, etc.,—is such as would substantiate the claims made; if the yield reported were 5,500 lbs. of milk or 290 lbs. of butter, our conclusion would be the same.

There is sometimes a discrepancy between the yields of milk and butter reported, and the per cent. of the fat in milk; this may be due to a too high fat content of the av-

erage milk of the year being given, or the fact that the butter equivalent of the milk consumed by the family has not been included in the butter yield. In ordinary dairy practice where a separator is used, and where the cream is properly ripened before churning, the yield of butter will exceed the quantity of butter fat produced by about 15 per cent.; 100 lbs. of 4 per cent. milk will give about 4.6 lbs. of butter, 100 lbs. of 3.8 per cent. of milk, 4.37 lbs. of butter, etc. Where the milk is set by gravity methods, and the churning is not done very carefully, the yield of butter may easily fall to that of the fat in the milk or even below.

The names of the farmers furnishing the winter rations fed to their herds, with information concerning the management of these, are given in the following tables.

American Farmers Furnishing Rations for Dairy Cows, 1892-3.

ABBREVIATIONS—For breeds: A.—Ayrshires; B. S.—Brown-Swiss; D.—Devons; G.—Guernseys; Gr.—Grade stock; H.—Holstein-Frieseans; J.—Jerseys; N.—Natives; R. P.—Red Polled; S.—Short Horns.
For specialty of farming: B.—Production of butter; Br.—Breeding; C.—Production of cream; G. P.—General purpose; M.—Production of milk.

No.	Name.	Post Office.	No. of cows giving milk.	Breed.	Av. weight of cows, Lbs.	Annual Yield per Cow. Milk. Lbs.	Annual Yield per Cow. Butter. Lbs.	Per cent. fat in Milk.	Specialty of farming.	Cows go dry, Weeks.
	Colorado.									
1	J. W. Goss	Hygiene	20	J.	900	5,000	340	5.0	C. and B.	None over 8; half not at all.
2	E. B. Haver	Pueblo	90	H.	1,180	9,030	....	....	M. and C. for city.	4-6.†
3	C. F. Hunt	New Windsor	40	J. H.	1,025	10,000	....	4.25	Br. for M & B.	4-6.†
4	W. C. Stiles	Loveland	16	H.	1,100	6,800	270	....	Br. dairy stock	8, July-Aug.
	Connecticut.									
5	E. S. Henry	Rockville	32	J.	900	....	375	....	Br. thorough-bred stock & B.	Mostly in summer.
	Illinois.									
6	A. Bourquin	Nokomis	12	B. S.	1,400	....	415	....	G. P.	2-4.*
7	J. H. Delancey & Son	Elgin	82	H.	1,200	9,937	....	....	Br. & M.	8.†
8	H. B. Gurler	DeKalb	67	Gr. H. J. S.	1,000	6,200	271	4.33	B.	8, July and August.
9	J. G. Spicer	Edelstein	30	J.Gr.J.H.S.	950	....	250	4.20	B.	2-3, July and Aug.*
10	I. U. Wetmore	Oneida	6	S. & H.	1,100	....	....	....	M. for cheese factory	Av. 8, Jan.-Apr.*
	Indiana.									
11	Mrs. Kate M. Busick	Wabash	20	J.	800	4,500	300	5.9	Br. & B.	4, Aug. and Sept.*
12	C. C. Richards	Howland	22	J.	750	5,100	300	....	M.	4-6.†

* Some cows do not go dry at all. † Cows come in at all seasons.

American Farmers Furnishing Rations for Dairy Cows. 1892-3—Continued.

No.	Name.	Post Office.	No. of cows giving milk.	Breed.	Av. weight of cows, Lbs.	Annual Yield Per Cow. Milk, Lbs.	Annual Yield Per Cow. Butter, Lbs.	Per cent. fat in milk.	Specialty of farming.	Cows go dry, Weeks.
13	W. C. Wheatcraft	Greenwood	8	J.	800	4,500	300	....	Br. for M. & B.	In fall; heifers in spring.
	Iowa.									
14	C. L. Gabrilson	New Hampton	22	J. & S.	1,000	4,200	200	4.9	B.	8.†
15	J. L. Hoyle	Springville	8	J.	800	6,000	305	5.5	B. & Br. for B.	4.†
16	Jno. M. Sterr	New Hampton	10	S.	1,000	3,850	155	....	G. P.	6-8, Jan. & Feb.
	Kansas.									
17	H. W. Cheney	North Topeka	25	H.	1,300	....	....	3.6	Br. & M.	6-8.†
	Kentucky.									
18	Newton Frazier	Clark's Station	20	J.	900	....	....	....	Br.	90 perct. never dry.†
	Massachusetts.									
19	Geo. L. Clemence	Southbridge	20	Gr.	1,050	5,400	....	3.9	M. for market	7.
20	F. H. Foster	Andover	10	G. J. Gr.	900	5,500	....	....	M. for market	6-8.†
21	O. F. Fuller	Blackstone	9	J.	800	5,000	....	....	M. & B.	4.†
	Michigan.									
22	O. McVittie	Detroit	9	J.	850	....	284	....	B.	4 *†
23	M. Nelson	Menominee	32	Gr.	1,100	6,124	....	....	M.	6-8.†
	Minnesota.									
24	W. J. Boynton	Rochester	12	H.	1,400	10,000	....	3.6	Br.	4-5.

† All Seasons. * Some not at all.

25	Ph. Peteler, Supt. North Oaks Stock Farm	righton....	40	Gr. S.	1,200	8,500	300	....	Br..................	*.
26	S. W. Wheaton............	Caledonia.........	8	G. S.	1,060	5,060	220	....	B..................	July and Aug.
	Nebraska.									
27	T. G. Ferguson............	Stelia	30	H.	1,300	....	....	5.8	Br. & B	4.†
28	F. H. Vaughan............	Fremont..........	30	J.	1,000	4,050	270	....	B. & Br..........	4, Aug. and Sept.
	New Hampshire.									
29	W. D. Baker...	Quincy........ ...	12		900	5,500	312	....	Br. & B	6, July and Aug.*
30	Ch H. Hayes & Sons.......	Portsmouth	32	A.‡	1,100	6,000	....	....	Br. & M..........	8.
	New Jersey.									
31	John Mayer	Mahwah..........	150	J.	1,000	5,000	350	4.1	M. C. B..........	†.
	New York.									
32	Alex. Burns	Bovina...........	22	J.	800	....	325	5.4	Br. & B..........	6.
33	A. S. Cotton, Mgr. Sanatorium Farm	Clifton Springs...	106	H., a few A. and Gr. G.	1,100	5,650	....	4.0	M. & B..........	4-6.†
34	H. M. Cottrell, Supt. Ellerslie Stock Farm..........	Rhinecliff	80	G.	1,000	6,120	....	5.8	Rich M. & gilt edge B.........	8.†
35	F. E. Dawley...............	Syracuse	10	J.	812	....	306	5.5	B. & Calves......	4.†
36	M. C. Denton, Supt. Hillside Stock Farm............	Elmira	30	G.	1,050	....	....	4.6	Br. & B.........	8.†
37	Paul Devereaux...........	Deposit...	60	J.	800	4,534	250	....	B.	4-8, July & Aug.
38	John P. Douglass.........	Theresa	70	Gr. H.	1,100	5,043	....	3.6	M.....	4-6, Fall.
39	Frank Eno................	Pine Plains.......	60	J.	1,000	4,800	....	....	M. & Br...... ...	6-8, July & Aug.
40	H. S Matteson............	Morris...........	14	J. Gr. J.	900	....	240	....	Br. & B........	6, Feb. & Mch.
41	——————............	Bovina Center....	10	J.	850	....	275	....	B................	8-12, Winter.
42	D. A. Oliver....	Bovina Center...	38	J.	900	....	275	4.0	B................	8, Dec. & Jan.

‡ Jersey-Holstein crossbreds; thoroughbreds on both sides. † All seasons. * Some not at all.

American Farmers Furnishing Ration for Dairy Cows, 1892-3.—Continued.

No.	Name.	Post Office.	No. of cows giving milk.	Breed.	Av weight of cows. Lbs.	Annual Yield per Cow.		Per cent. fat in milk.	Specialty of farming.	Cows go dry, Weeks.
						Milk. Lbs.	Butter. Lbs.			
43	C. G. Peters	East Williston	5	J.	725	....	....	....	B.	*
44	J. E. Rogers	Binghampton	60	N.	1,000	6,538	....	4.2	M.	8, June & Jul
45	Geo. W. Sisson	Potsdam	29	J.	800	5,000	300	5.2	Br. M. & B.	2-4. †*
46	Smiths & Powell Co.	Syracuse	60	H.	1,200	12,000	....	....	Br. &. B.	0-6. †
47	Dixon Thompson	Bovina Center	32	Gr. J.	800	....	295	....	B.	4-8, Jan. & Feb.
48	J. Van Wagenen	Lawyersville	28	N. & Gr. J.	1,100	....	260	5.2	B.	2-8. †
49	Menzo Wilcox	Milford	9	D. & N.	785	9,200	373	....	B.	4, Jan. & Feb. *
50	A Doncourt, Mgr. The Old Brick Farm	Roslyn	30	G.	1,000	7,300	497	5.7	Br.	* †
51	D. P. Witter	Richford	19	Gr. H.	1,100	7,493	....	....	M. & Beef	3-6, in Autumn.
	North Carolina.									
52	E. B. C. Hambley	Rockwell	25	J.	800	6,000	330	....	Choice B.	1. †
	North Dakota.									
53	W. O. Ward	Bismarck	58	J. H. N.	1,100	....	....	....	M.	10. †
	Ohio.									
54	Chr. Hintz	Fremont	11	S.	1,500	....	....	....	Beef, M. & B.	4-6. † e..cept July & Aug.
	Ohio.									
55	John Gould	Aurora Sta.	12	Gr. & N.	1,000	5,900	....	4.2	M.	8-10, in summer.
56	J. McLain Smith	Dayton	12	R. P.	1,250	6,000	....	4.3	B.	3-6.†

† All seasons. * Some not at all.

57	B. B Overmeyer	Lindsey	9	S.	1,125	4,750	165	4.2	Beef, M & B	8.†
58	Henry Talcott	Jefferson	20	Gr. G.	1,200	5,000	250	....	Br. & B	4-6, Aug.
	Pennsylvania.									
59	E. E. Critchfield	Mt. Pleasant	20	H. S.	1,160	7,000	....	3.68	M	4-8.†
60	Geo. Fox	Torresdale	13	J.	950	....	....	....	M. & B	8.†
61	John C. McClintock	Meadville	24	J.	900	5,565	370	....	Gilt-edge B	3 6.†
62	Ezra Michener	Carversville	15	G.	950	6,200	325	5.0	Br. & B	4.†*
63	Miller & Sibley	Franklin	40	J. & S.	925	....	....	....	Br. & B	6-8.†
64	J. B. Phelps	Conneautville	21	All kinds	900	6,000	....	3.75	M. & B	3-6.
65	E. Reeder	New Hope	15	J.	800	3,000	200	6.0	B	2 †
66	J. L. Stone	Waverley	20	J.-H.	1,000	6,000	....	3.8	Br. & M	4-8, July & Aug.
67	A. P. Young	Millville	9	J.	950	....	....	5.12	C. & calves	Come in Aug.-Sept.*
	Texas.									
68	Harwood & Le Baron Bros.	Prairie Lea	45	J.	850	5,250	336	5.7	B. & Br	4-6.†
	Utah.									
69	H. J. Faust, Jr., Supt. Netherland Fine Stock & D. Co.	Lehi	96	H. Gr. S.	1,200	6,500	....	3.5	M	4-6.†
	Vermont.									
70	T. G. Bronson	East Hardwick	25	J.	800	....	300	....	B. & Br	8.†
71	L. S. D e v	Burlington	25	A.	1,000	5,540	....	4.3	B. & Br	8.
72	L. C. Fis er	Cabot	27	J.	900	....	404	....	B	6-8, in summer.
73	H. W. Vail	North Pomfret	20	J.	700	....	285	5.1	B & Br	6-8, July and Aug.
74	C. M. Winslow	Brandon	30	A.	1,000	6,187	....	4.25	Br. & M	0-8.†
	West Virginia.									
75	R. K. Giffin	Wheeling	42	J.	800	5,780	405	5.9	M & B	2-6, summer & fall.

† All seasons.

* Some not at all.

American Farmers Furnishing Rations for Dairy Cows, 1892-93—Continued.

No.	Name.	Post Office.	No. of cows giving milk.	Breed.	Av. weight of cows, Lbs.	Annual Yield Per Cow.		Per cent. fat in milk.	Specialty of farming.	Cows go dry, Weeks.
						Milk. Lbs.	Butter. Lbs.			
	Washington.									
76	Brown Bros	Spokane	120	Gr.S J.H.N	1,200	....	....	....	M. & beef	*
	Wisconsin.									
77	C. R. Bridgman	Lamont	23	Gr.S H.G.	1,200	5,000	....	4.7	B.	†
78	C H. Everett	Beloit	14	J. G.	900	6,000	300	4.9	B.	July-Aug.
79	C P. Goodrich	Fort Atkinson	27	Gr. J.	900	5 500	320	5.25	B.	6-8, July-Aug.
80	H. D. Griswold	West Salem	9	Gr. S. G.	1,000	7,052	303	4.75	B	4-5, July-Sept.
81	S E. Guernon	Waukesha	30	Gr. J.	850	5,000	332	5.8	B.	4-6.†
82	Geo. Hodgson	Pewaukee	19	J G.	800	6,270	298	4.5	B.	6.†
83	John Hodgson, Jr	Pewaukee	21	J. Gr. G.	1,000	5,225	290	....	C.	† except June-July.
84	R. S. Houston	Ranney	45	J. G.	825	6,235	....	....	M.	6.†
85	A. X. Hyatt	Sheboygan Falls	28	Mostly S.	1,200	8,000	....	4.1	B. M	7-10, Jan.-March.
86	Chas. Linse	La Crosse	43	Gr. J.	950	....	289	4.7	B.	†
87	A. F. Noyes	Beaver Dam	20	S.	1,000	....	....	....	Beef, M. B	8.†
88	C. A. Salisbury	Clinton	11	Gr. J. S H.	1,100	6,500	....	3.8	M.	July-Aug.
89	C Thorp	Burnett Jct	13	Gr J. N.	1,000	6,000	321	4.8	B.	8, July-Aug.
90	M. Tourt[illegible]otte.	La Crosse	20	H. N.	1,000	....	....	....	B.	8-16.*
91	Widman Bros	Fort Atkinson	24	N. Gr. S. H.	1,150	7,456	325	3.9	B.	4-6, Aug.-Sept.*

* Some not at all. † All seasons.

	Canada.									
92	Herman Bollert............	Cassel	10	H.	1,300	10,000	....	4.0	Br & M..........	4-6.†
93	D. McPherson..............	Lancaster........	60	N.	900	5,000	....	4.0	Br. & M...........	4-8.
94	John Pringle...............	Ayr...............	10	H.	1,150	....	286	....	Br. & B...........	6.*
95	R. Reesor....................	Locust Hill.......	25	J.	1,000	....	....	....	C........	1-2.†
96	A. & G. Rice........... ...	Curries...........	25	H.	1,200	9,000	....	3.9	Br. & M...........	8, Feb.-March.
97	Smith Bros..................	Churchville......	34	H.	1,200	10,000	....	3.84	Br. for M. & B....	4-6, Aug.-Sept.
98	J. Yuill & Son.....	Ca·leton Place ...	22	A.	900	....	....	....	Br. & B...........	8, Sept. -Oct.*
99	J. E. Page & Sons..........	Amherst, N. S....	22	HJGrHJS	1,200	7,500	....	....	Br. & M..........	6.†
100	R. Robertson...............	Howick, Que	23	A.	1,000	8,000	360	4.0	M. & Br..........	8, Sept.-Nov.

*Some not at all. †All seasons.

AMERICAN RATIONS FOR DAIRY COWS.

The following rations were furnished by the farmers whose names are given in the preceding table, the numbers corresponding to those in the table. As before stated, the weights in many cases have no claim to absolute accuracy; from the nature of the problem it would usually be extremely difficult to ascertain the exact average quantities of the different feed stuffs eaten by cows in the various herds. In some cases, especially the coarse fodder may have been somewhat overestimated; in other cases average feeds were actually weighed; in general it is, however, believed that the rations given correspond fairly well with the food actually consumed daily by the cows in the different herds, and that they may safely be made the basis of discussions of the distinctive systems of feeding practiced by the various dairymen and breeders.

100 *American Rations for Dairy Cows.*

Colorado.

1.—30 lbs. corn silage, 10 lbs. alfalfa hay, 10 lbs. clover hay, 5 lbs. roller bran, 2 lbs corn meal.

2.—20 lbs. alfalfa hay, 10 lbs. corn fodder, 8 lbs. cotton seed meal, 4 lbs. corn meal, 13 lbs. bran, 35 lbs mangolds,

3.—20 lbs. alfalfa hay, 5 lbs. oat straw, 2½ lbs. wheat bran, 2½ lbs. shorts, 5 lbs. oats, 1½ lbs. cotton seed meal.

4.—40 lbs. corn silage, 15 lbs. alfalfa hay, 4 lbs. bran, 4 lbs. corn chop.

Connecticut.

5.—35 lbs. corn silage, 10 lbs. hay, 3 lbs. bran. 3 lbs. corn and cob meal, 2 lbs. cottonseed meal, 2 lbs. Chicago gluten meal.

Illinois.

6.—7½ lbs. clover hay, 7½ lbs. timothy hay, 12 lbs. corn and cob meal, 8 lbs. bran, 1½ lbs. linseed meal, 1½ lbs. cotton seed meal.

7.—15 lbs. corn stalks, 4 lbs. of hay, 3½ lbs. hominy meal, 3½ lbs. shorts, 3½ lbs. wheat bran, 3½ lbs. buckwheat bran.

8.—50 lbs. of corn silage, 4 lbs. wheat shorts, 4 lbs grano gluten.

9.—40 lbs. corn silage, 8 lbs. timothy hay, 4 lbs. bran, 2 lbs. corn meal, 1 lb. oats.

10.—10 lbs. timothy hay, 10 lbs. clover hay, 8 lbs. corn, 1½ lbs. oats.

Indiana.

11.—30 lbs. corn silage, 5 lbs. clover hay, 3 lbs. corn fodder, 1 lb. oat straw, 1 lb. wheat straw, 5 lbs. bran, 2 lbs. oil meal, 2 lbs. cotton seed meal.

12.—6 lbs. corn fodder, 12 lbs. clover hay, 4 lbs. wheat bran, 4 lbs. hominy meal, 1 lb. linseed meal.

13.—24 lbs. corn fodder, 5 lbs. corn meal, 3½ lbs. bran, 1½ lbs. oil meal, ½ lb. cotton seed meal.

Iowa.

14.—50 lbs. corn silage, 5 lbs. hay, 5 lbs. corn fodder, 1 lb. oat straw, 1 lb. barley straw, 5 lbs. ear corn, 2½ lbs. ground oats and barley.

15.—40 lbs. corn silage, 5 lbs. timothy and clover hay, 7 lbs bran or shorts.

16.—20 to 25 lbs. clover hay, 12.7 lbs. corn, 4.9 lbs. oats..

Kansas.

17.—50 lbs. sorghum fodder; 7½ lbs. of hay, 3.2 lbs. of bran, 3.2 lbs. of corn meal, 1½ lbs. oil meal.

Kentucky.

18.—32.5 lbs. corn silage, 6 lbs. clover hay, 3 lbs. corn fodder, 5 lbs. corn meal, 4 lbs. ship stuff, 2 lbs. oil meal.

Massachusetts.

19.—40 lbs. corn silage, 5 lbs. English hay, 5 lbs. clover hay, 2 lbs. bran, 2 lbs. gluten meal, 1 lb. cotton seed meal, 1 lb. linseed meal.

20.—40 lbs. corn silage, 6 lbs. hay, 2 lbs. gluten meal, 2 lbs. corn and cob meal, 2 lbs. shorts.

21.—12 lbs. timothy hay, 10 lbs. rowen, 1.8 lbs. shorts, 2.6 lbs. corn meal, 3 lbs. cotton seed meal.

Michigan.

22.—27.5 lbs. corn silage, 3½ lbs. clover hay, 3½ lbs. timothy hay, 3.6 lbs. bran, ½ lb. oats, 1 lb. rye, ½ lb. linseed meal.

23.—24 lbs. timothy hay, 4 lbs. oat fodder, 4 lbs. rye fodder, 12 lbs. middlings, 5 lbs. dried brewers' grains.

Minnesota.

24.—50 lbs. corn silage, 8 lbs. hay, 3 lbs. bran, 2 lbs. shorts, 3 lbs. ground rye and oats, 2 lbs. barley.

25.—8 lbs. corn fodder, 7 lbs. clover and timothy hay, 5 lbs. sheaf oats, 3 lbs. rutabagas, 2 lbs. bran, 3 lbs. oats, 3 lbs. corn meal, 2 lbs. oil cake.

26.—23 lbs. clover and timothy hay, 10 lbs. ground barley.

Nebraska.

27.—10 lbs. clover hay, 35 lbs. silage, 2 lbs. oat straw, 5 lbs. corn meal, 5 lbs. bran, 5 lbs. oats.

28.—20 lbs. prairie hay, 10 lbs. corn fodder, 5.7 lbs. corn meal, 2.9 lbs. bran, 1.4 lbs. oil meal.

New Hampshire.

29a.—10 lbs. clover and witch grass hay, 10 lbs. corn stover, 5 lbs. unthrashed barley, 2 lbs. corn and cob meal, 2 lbs. shorts, 2 lbs. cotton seed meal.

29b.—11.7 lbs. clover and witch grass hay; 3.3 lbs. oat straw, 10 lbs. meadow hay, 2 lbs. shorts, 2 lbs. corn and cob meal, 1 lb. ground pease, 1 lb. oats, 1 lb. barley.

29c.—10 lbs. meadow hay, 10 lbs. corn stover, 5 lbs. pea straw, 2 lbs. middlings 1½ lbs. gluten meal, 1½ lbs. cotton seed meal, 2 lbs. corn and cob meal.

29d.—10 lbs. clover and witch grass hay, 10 lbs. meadow hay, 5 lbs. pea straw, 2 lbs. shorts, 1 lb. gluten meal, 1 lb. cotton seed meal, 2 lbs. corn and cob meal.

30.—35 lbs silage, 7 lbs. hay, 20 lbs. brewers' grains, 1½ lbs. gluten meal, 1½ lbs. cotton seed meal, 1½ lbs. shorts, 1½ lbs. linseed meal.

New Jersey

31a.—24 lbs. corn silage, 8 lbs. corn meal, 2 lbs. bran, 4 lbs. oats, 2 lbs. oil meal.

31b.—24 lbs corn silage, 4 lbs. corn meal, 2 lbs. bran, 6 lbs. oats, 2 lbs. oil meal.

New York.

32.—20 lbs. hay, 2 lbs. bran, 2 lbs. cotton seed meal, 2 lbs. hominy meal.

33a.—40 lbs. corn silage, 10 lbs. corn fodder, 2½ lbs. cotton seed meal, 2 lbs. N. P. linseed meal, 4 lbs. wheat bran.

33b.—35 lbs. prickly comfrey, 10 lbs corn fodder, 2½ lbs. cotton seed meal, 2 lbs. N. P. linseed meal, 4 lbs. wheat bran.

34.—25 lbs. corn silage, 7 lbs. mixed hay, 4 lbs. corn meal, 5 lbs. bran, ½ lb. oil meal, ½ lb. cotton seed meal.

35.—40 lbs. corn silage, 15 lbs. hay, 2 lbs. linseed meal, 4 lbs. wheat bran, 2 lbs. corn meal, 2 lbs. oat meal.

36.—40 lbs. corn silage, 10 lbs. timothy hay, 5 lbs. wheat bran, 3 lbs. corn meal, 2 lbs. oil meal.

37.—50 lbs. corn silage, 5 lbs. hay, 4 lbs. bran, 2 lbs. linseed meal, 1 lb. cotton seed meal, 1 lb. ground rye.

38.—28 lbs. of hay, 4 lbs. ship stuff.

39.—20 lbs. hay, 2½ lbs. bran, 4½ lbs corn and cob meal.

40.—15 lbs. clover hay, 4 lbs. corn stover, 4 lbs. timothy hay, 1.3 lbs. corn meal, ½ lb. oats, ½ lb. bran, 5.7 lbs. carrots.

41.—40 lbs. corn silage, 15 lbs. hay, 5 lbs. bran, 2 lbs. cotton seed meal, 3 lbs. corn meal.

42.—23 lbs. hay, 4 lbs. bran, 2 lbs. cotton seed meal, 2 lbs. corn meal.

43a.—30 lbs. corn fodder, 2.3 lbs. ground oats, 1.2 lbs. corn meal, .6 lb. bran, .6 lb. oil meal.

43b.—30 lbs. corn fodder, 3 lbs. corn meal, 1.6 lbs. ground oats, .8 lb. bran, .8 lb. linseed meal.

44.—40 lbs. corn silage, 3 lbs. cotton seed meal, 18 lbs. corn-starch feed.

45.—30 lbs. corn silage, 12 lbs. clover hay, 8 lbs. wheat middlings, 1 lb. oil meal.

46.—40 lbs. corn silage, 15 lbs. hay, 9 lbs. wheat bran, 4½ lbs. germ meal, 1 lb. oats, 1 lb. wheat, 1 lb. barley, 1 lb., corn, ½ lb. linseed meal.

47.—20 lbs. hay, 2½ lbs. cotton seed meal, 2½ lbs. corn meal, 3 lbs. shorts.

48.—9 lbs. clover hay, 9 lbs. timothy hay, 5 lbs. corn fodder, 5 lbs. of oat and pea straw, 1 lb of oats, 1 lb. buckwheat middlings, 1 lb. corn, 1 lb. rye bran, 1 lb. wheat bran, 1.6 lbs. cotton seed meal.

49.—12 lbs. timothy hay, 1 lb. bran, 1 lb. middlings, 2 lbs. corn meal, 2 lbs. cotton seed meal, 40 lbs. skim milk.

50.—42 lbs. corn silage, 2½ lbs clover hay, 2½ lbs. timothy hay, 8 lbs. corn and cob meal, 14 lbs. dried brewers' grains.

51.—35 lbs. corn silage, 4 lbs. clover hay, 4 lbs. timothy hay, 2 lbs. wheat bran, 5 lbs. cotton seed meal.

North Carolina.

52.—30 lbs. corn silage, 8 lbs. fodder corn, 3 lbs. corn meal, 3 lbs. bran, 1 lb. cotton seed meal.

North Dakota.

53.—32 lbs. prairie hay, 6 lbs. bran.

Ohio.

54.—25 lbs. clover hay, 34 lbs. mangolds, 3 lbs. corn and cob meal, 1½ lbs. oats, 2 lbs. wheat bran.

55.—50 lbs. corn silage, 8 lbs. clover hay, 5 lbs. "seconds".

56.—30 lbs. corn silage, 8 lbs. corn stover, 5 lbs. bran, 4 lbs. malt sprouts, 1 lb. oil meal.

57.—10 lbs. clover hay, 20 lbs. corn stalks, 8 lbs. corn meal, 3 lbs. corn and cob meal, 1 lb. bran, 8 lbs. roots.

58.—50 lbs. corn silage, 9 lbs. clover hay.

Pennsylvania.

59.—45 lbs. corn silage, 7 lbs. mixed hay, 6 lbs. bran, 2 lbs. cotton seed meal.

60.—10 lbs. clover hay, 5 lbs. timothy hay, 2½ lbs corn fodder, 6½ lbs. corn meal, 2 lbs. oats, 3.2 lbs. bran, 1½ lbs. oil meal, 15 lbs. carrots.

61.—24 lbs. corn fodder, 5.1 lb. bran, 5.1 lbs corn meal, .3 lbs. cotton seed meal, 2 lbs. oil meal.

62.—10 lbs. corn fodder, 6 lbs. hay, 3½ lbs. bran, 1½ lbs. cotton seed meal, 1½ lbs. oil meal, 2½ lbs. corn meal.

63.—15 lbs. corn silage, 22 lbs. sugar beets, 10 lbs. hay, 5.4 lbs. oats, 7 lbs. corn meal.

64.—40 lbs corn silage, 8 lbs. clover hay, 6 lbs. coarse linseed meal.

65.—10 lbs. hay, 5 lbs. corn fodder, 6 lbs. corn meal, 3 lbs. wheat bran.

66.—40 lbs. corn silage, 10 lbs. mixed hay, 4 lbs. corn meal, 4 lbs. wheat bran, 2 lbs. cotton seed meal.

67.—40 lbs. corn silage, 7 lbs. hay, 1 lb. straw, 2 lbs. oil meal, 2 lbs. corn and cob meal, 2 lbs. wheat bran.

Texas.

68.—30 lbs. corn silage, 13½ lbs. sorghum hay, 1.3 lbs. corn meal, 2.6 lbs. cotton seed meal, 2.2 lbs. cotton seed, 1.3 lbs. wheat bran.

Utah.

69.—35 lbs. alfalfa hay, 6½ lbs. wheat bran, 3½ lbs. barley.

Vermont.

70.—35 lbs. corn silage, 10 lbs. mixed hay, 2 lbs. bran, 3.2 lbs. corn meal, 1 lb. linseed meal, .8 lb. cotton seed meal.

71.—20 lbs. corn silage, 14 lbs. hay, 3 lbs. bran, 2 lbs. gluten meal.

72.—30 lbs. corn silage, 10 lbs. hay, 4.2 lbs. corn meal, 4.2 lbs. bran, .8 lb. linseed meal.

73.—30 lbs. corn silage, 10 lbs. hay, 2 lbs. corn meal, 2 lbs. gluten meal, 2 lbs. bran.

74.—30 lbs. hay, 1.8 lbs. wheat bran, .9 lb. wheat middlings.

West Virginia.

75.—48 lbs. corn silage, 2½ lbs. corn and cob meal, 2½ lbs. ground wheat 2½ lbs. oats, 2½ lbs. barley meal.

Washington.

76.—15 lbs. alfalfa hay, 7 lbs. bran, 7 lbs. shorts, 2 lbs. malt sprouts.

Wisconsin.

77.—30 lbs. corn silage, 8 lbs. hay, 5 lbs. corn fodder, 4 lbs. oats, 2 lbs. pea meal.

78.—40 lbs. corn silage, 8 lbs. clover hay, 6 lbs. bran, 2 lbs. pea meal.

79.—32 lbs. corn silage, 5 lbs. clover hay, 5 lbs. corn stalks, 8 lbs. bran, 2 lbs. cotton seed meal, 2 lbs. oat straw.

80.—12 lbs. timothy hay, 5½ lbs. corn fodder, 6 lbs. corn meal, 2 lbs. oats, 2 lbs. barley, 5 lbs. bran, 7½ lbs. potatoes.

81.—26 lbs. corn silage, 10 lbs. clover hay, 5 lbs. timothy hay, 8 lbs. wheat middlings, 1½ lbs. oil meal.

82.—25 lbs. uncut corn silage, 10 lbs. clover hay, 9 lbs. bran.

83.—40 lbs. corn silage, 5 lbs. clover hay, 5 lbs. timothy hay, 4½ lbs. bran, 4½ lbs. middlings.

84.—45 lbs. corn silage, 12 lbs. clover hay, 8 lbs. shorts, 4 lbs. corn meal.

85.—25 lbs. roots, 8 lbs. oat meal, 3 lbs. oil meal, 15 lbs. hay, 10 lbs. corn fodder, 4 lbs oat straw.

86.—22 lbs. corn silage, 4 lbs. clover hay, 4 lbs. timothy hay, 2 lbs. oat straw, 2 lbs. corn stalks, 6 lbs. wheat screenings, 2 lbs. malt sprouts, 2 lbs. oil meal, 1 lb. wheat bran.

[illegible] lbs. corn silage, 15 lbs. corn fodder, 5 lbs. clover hay, 5 lbs. bran.

—9 lbs. corn fodder, 9 lbs. clover hay, 1 lb. barley straw, 4 lbs. corn meal, 3 lbs. barley meal, 3 lbs. bran.

89.—40 lbs. corn silage, 10 lbs. fodder corn, 2 lbs. corn stalks, 2 lbs. oat straw, 5 lbs. ground oats, 5 lbs. barley.

90.—17 lbs. corn silage, 17 lbs. timothy hay, 1.7 lbs. corn stalks, 2 lbs. oat straw, 1.7 lbs. oil meal, 2.7 lbs. oats, 1.7 lbs. bran.

91.—50 lbs. corn silage, 5 lbs. sheaf oats, 5 lbs. corn fodder, 1 lb. clover hay, 1 lb. millet, 2.7 lbs. cotton seed meal, 1.3 lbs. of oil meal, 6 lbs. bran.

Canada.

92.—40 lbs. corn silage, 5 lbs. hay, 5 lbs. straw, 4½ lbs. bran, 4½ lbs. oats.

93.—45 lbs. corn silage, 5 lbs. hay, 5 lbs. bran, 3 lbs. cotton seed meal.

94.—45 lbs. turnips, 7 lbs. of wheat chaff, 15 lbs. silage, 2½ lbs. oats, 2½ lbs. pea meal.

95.—30 lbs. corn silage, 12 lbs. hay, 10 lbs. ground oats.

96.—40 lbs. corn silage, 30 lbs. turnips, 8 lbs. clover hay, ½ lb. straw, 2 lbs. oats, 2 lbs. wheat bran.

97.—50 lbs. corn silage, 10 lbs. clover hay, 3 lbs. straw, 5 lbs. pea meal, 2 lbs. oats.

98.—30 lbs. corn silage, 7½ lbs. hay, 6½ lbs. straw, 25 lbs. turnips, 1.3 lbs. pea meal, 2.5 lbs. oats, 1.3 lbs. barley.

99.—35 lbs. corn silage, 8 lbs. English hay, 30 lbs. carrots, 1.2 lbs. bran, 1.8 lbs. middlings, 3 lbs. cotton seed meal, 1 lb. oat, 2 lbs. wheat.

100.—40 lbs. corn silage, 7½ lbs. clover hay, 3 lbs. straw, 1½ lbs. oats, 1½ lbs. barley, 1½ lbs. pea meal, 3 lbs. wheat bran, 1 lb. cotton seed meal.*

* In Bulletin No. 38 of this Station, of which the present article is largely a reprint, extracts from correspondence with the farmers furnishing the preceding rations are given; the extracts throw a great deal of light on the systems of farming followed, farmers' opinions concerning the feeding value of different cattle foods, etc., but space forbids more than a mere reference to the Bulletin at this place.

NUTRIENTS IN PRECEDING RATIONS.

The nutrients in the rations given in the preceding pages are shown in the following table. The composition and the digestibility of the various feed stuffs were taken from the compilation published in the latter part of the report. For an explanation of technical terms used in the table and in discussions throughout this report, see the chapter on Composition of Feeding Stuffs by the writer. For the sake of comparison the components of the rations have been calculated per 1,000 lbs. live weight.

Nutrients in 100 American winter rations for dairy cows, in lbs.

No.	Organic matter.	Digestible Matter.				Nutr. Ratio.
		Protein.	Carbhydr.	Fat.	Total.	
Colorado.						
1	31.09	2.70	15.78	.80	19.28	1:6.5
2	35.65	4.34	18.12	1.10	23.56	1:4.7
3	30.09	3.14	14.01	.81	17.96	1:5.0
4	24 92	2.06	13.35	.70	16.11	1:7.2
Average	*30.44*	*3.06*	*15.32*	*.85*	*19.23*	*1:5.6*
Connecticut.						
5	*25.70*	*2.69*	*13.96*	*.97*	*17.62*	*1:6.0*
Illinois.						
6	22.09	2.37	12.06	.75	15.18	1:5.8
7	19.06	1.50	10.67	.51	12.68	1:7.9
8	19.20	2.17	10.24	.93	13.34	1:5.7
9	23.36	1.58	13.24	.65	15.47	1:9 3
10	22.72	1.60	13.02	.65	15.27	1:9.0
Average	*21.29*	*1.84*	*11.85*	*.70*	*14 39*	*1:7.9*
Indiana.						
11	26.08	3.24	12.94	1.07	17.23	1:4.7
12	27.03	2.76	14.30	.90	17.96	1:5.9
13	27.81	2.54	16 61	.92	20.07	1:7 3
Average	*26 97*	*2.85*	*14 61*	*.96*	*18.42*	*1:5.9*

Nutrients in 100 *American winter rations for dairy cows, in lbs.*—continued.

No.	Organic matter.	Digestible Matter. Protein.	Carbhydr.	Fat.	Total.	Nutr. Ratio.
Iowa.						
14	24.77	1.34	15.01	.76	17.11	1:12.8
15	22.06	1.81	12.16	.70	14.67	1:7.6
16	32.80	2.81	18.00	1.09	21.90	1:7.3
Average	*26.58*	*1.99*	*15.05*	*.85*	*17.89*	*1:8.5*
Kansas						
17	*17.39*	*1 36*	*10.43*	*.48*	*12.27*	*1:8.5*
Kentucky.						
18	*24.62*	*2.38*	*14.04*	*.91*	*17.33*	*1:6.7*
Massachusetts.						
19	19.96	2.15	10.43	.75	13.33	1:5.7
20	19.72	1.53	11.30	.63	13.46	1:8.8
21	30 31	2.80	15.63	.99	19.42	1:6.4
Average	*23 33*	*2.16*	*12.45*	*.79*	*15.40*	*1:6.6*
Michigan.						
22	18.45	1.45	10.08	.55	12.08	1:7.8
23	34.32	2.41	18.49	.74	21.64	1:8.3
Average	*26 39*	*1.93*	*14.28*	*.65*	*16 86*	*1:8.1*
Minnesota.						
24	19.09	1.40	11.10	.48	12.98	1:8.7
25	19.32	1.75	10.64	.60	12.99	1:6.8
26	25.61	1.92	14.75	.41	17.08	1:8.2
Average	*21 34*	*1.69*	*12.16*	*.50*	*14 35*	*1:7 9*
Nebraska.						
27	22.47	1.85	12.27	.71	14.83	1:7.5
28	29.96	2.15	17.18	.73	20.06	1:8.7
Average	*26.22*	*2.00*	*14 73*	*.72*	*17 45*	*1:8.2*
New Hampshire.						
29 a	25.50	2.39	14.37	.70	17.46	1:6.7
29 b	28.97	1.88	15.47	.53	17.88	1:8.8
c	26.12	2.24	13.65	.65	16.54	1:6.7
29 d	28.86	2.84	13.68	.82	17.34	1:5.5
30	20.33	2.51	10.19	.91	13 61	1:4 9
Average	*23 84*	*2.43*	*12.24*	*.79*	*15 46*	*1:5.8*

***Nutrients* in 100 *American winter rations for dairy cows, in lbs.*—continued.**

No.	Organic matter.	Digestible Matter. Protein.	Carbhydr.	Fat.	Total.	Nutr. Ratio.
New Jersey.						
31 a..........	19.41	2.06	11.71	.87	14.64	1:6.5
31 b..........	17.72	1.96	10.09	.79	12.84	1:6.0
Average.	*18.57*	*2.01*	*10.90*	*.83*	*13.74*	*1:6.0*
New York.						
32............	26.19	2.36	13.78	.79	16.93	1:6.6
33 a..........	21.41	2.63	11.42	.78	14.83	1:5.0
33 b..........	15.59	2.21	7.78	.54	10.53	1:4.1
34............	19.96	1.81	11.46	.66	13.93	1:7.1
35............	34.81	2.80	19.29	1.07	23.16	1:7.7
36............	23.38	1.94	13.15	.77	15.86	1:7.7
37............	25.92	2.39	14.99	1.07	18.45	1:7.3
38............	23.38	1.27	12.63	.36	14.26	1:10.6
39............	21.69	1.33	13.27	.40	15.00	1:10.6
40............	22.13	1.60	11.10	.47	13.17	1:7.6
41............	33.18	2.89	18.24	1.12	22.25	1:7.5
42............	27.75	2.44	14.65	.75	17.84	1:6.7
43 a..........	28.37	1.81	16.90	.85	19.56	1:10.4
43 b..........	30.14	2.01	18.19	.93	21.13	1:10.1
44............	18.29	2.62	9.95	1.06	13.63	1:4.7
45............	23.65	2.87	14.73	.88	18.48	1:5.8
46............	29.16	2.41	16.98	.85	20.24	1:7.8
47............	23.36	2.70	14.90	.88	18.48	1:6.2
48............	24.53	2.13	12.01	.67	14.81	1:6.3
49............	25.73	3.50	14.05	1.12	18.67	1:4.7
50............	31.30	3.37	16.31	1.31	20.99	1:5.7
51............	18.87	2.68	8.94	.84	12.56	1:4.1
Average.	*25.55*	*2.37*	*13.88*	*.84*	*17.09*	*1:6.6*
North Carolina.						
52............	*20.38*	*1.79*	*11.98*	*.80*	*14.57*	*1:7.7*
North Dakota.						
53............	*27.64*	*1.74*	*14.86*	*.45*	*17.05*	*1:9.1*

***Nutrients in* 100 *American winter rations for dairy cows, in lbs.*—continued.**

No.	Organic matter.	Digestible Matter.				Nutr. Ratio.
		Protein.	Carbhydr.	Fat.	Total.	
Ohio.						
54	18.53	1.72	9.07	.47	11.26	1:5.9
55	20.26	1.53	10.95	.63	13.11	1:8.1
56	16.77	1.91	9.13	.48	11.52	1:5.3
57	26.63	1.80	15.76	.67	18.23	1:9.6
58	15.98	1.03	8.48	.40	9.91	1:9.1
Average	*19.63*	*1.59*	*10.68*	*.53*	*12.80*	*1:7.5*
Pennsylvania.						
59	19.87	2.01	10.59	.69	13.29	1:6.0
60	27.55	2.60	17.47	.90	20.97	1:7.5
61	26.52	2.53	15.74	.90	19.17	1:7.0
62	20.05	2.31	11.00	.72	14.03	1:5.4
63	26.36	1.85	16.06	.79	18.70	1:9.6
64	23.43	2.82	11.53	.93	15.28	1:4.8
65	23.84	1.69	14.27	.64	16.60	1:9.3
66	24.23	2.20	13.54	.92	16.66	1:7.2
67	20.30	1.62	11.30	.64	13.56	1:7.8
Average	*23.57*	*2.18*	*13.50*	*.79*	*16.47*	*1:7.0*
Texas.						
68	*26.58*	*2.21*	*12.31*	*1.30*	*15.82*	*1:6.9*
Utah.						
69	*31.63*	*3.20*	*15.36*	*.57*	*19.13*	*1:5.9*
Vermont.						
70	25.99	2.06	14.57	.89	17.52	1:8.0
71	20.22	1.64	11.09	.48	13.21	1:7.4
72	24.23	1.86	14.03	.75	16.64	1:8.4
73	27.25	2.16	15.59	.79	18.54	1:8.0
74	26.06	1.42	14.02	.38	15.82	1:10.5
Average	*24.74*	*1.83*	*13.86*	*.66*	*16.35*	*1:8.4*
West Virginia.						
75	*22.37*	*1.54*	*14.15*	*.72*	*16.41*	*1:10.9*

***Nutrients in 100 American winter rations for dairy cows, in lbs.*—continued.**

No.	Organic matter.	Digestible Matter. Protein.	Carbhydr.	Fat.	Total.	Nutr. Ratio.
Washington.						
76	*21.60*	*2.68*	*10 54*	*.55*	*13.77*	*1:4.4*
Wisconsin.						
77	18.05	1.26	10.19	.44	11.89	1:8.9
78	25.16	2.40	13.60	.66	16.66	1:6.3
79	27.24	2.86	13.80	.92	17.58	1:5.5
80	27.34	2.01	16.50	.76	19.27	1:8.9
81	31.00	3.01	16.02	.87	19.90	1:6.0
82	23.68	2.34	12.17	.64	15.15	1:5.8
83	25.24	2.12	13.65	.68	16.45	1:7.1
84	34.32	2.85	18.79	1.12	22.76	1:7.5
85	26.90	2.11	14.43	.70	17.24	1:7.6
86	25.25	2.54	13.28	.66	16.48	1:6.2
87	22.13	1.66	12.32	.57	14.55	1:8.2
88	24.42	1.85	14.22	.59	16.66	1:8.4
89	24.79	1.59	15.02	.86	17.47	1:10.6
90	25.17	1.65	13.35	.62	15.62	1:8.9
91	23.79	2.73	12.46	.99	16.18	1:5.4
Average	*25.63*	*2.19*	*13.98*	*.74*	*16 91*	*1:7.1*
Canada.						
92	19.70	1.36	10.60	.53	12.49	1:8.7
93	23.95	2.78	12.46	.97	16.21	1:5.2
94	15.61	1.05	8.49	.31	9 85	1:8.7
95	23.98	1.58	13 07	.74	15.39	1:9.3
96	17.13	1.23	9.29	.51	11.03	1:8.5
97	23.78	2.03	12.89	.54	15.46	1:6.9
98	26.51	1.49	14.87	.57	16.93	1:10.8
99	20.52	2.23	11.44	.79	14.46	1:5.9
100	22.96	2.08	12.17	.71	14.96	1:6 6
Average	*21.57*	*1.76*	*11.69*	*.63*	*14.08*	*1:7.4*

DISCUSSION OF RESULTS.

Number of cows.—The hundred herds, the feeding of which we are here considering, contained in the aggregate 2,921 cows in milk during the winter of 1893; the herds contained from 5 to 150 animals, the average number being 29 animals.

Breeds represented.—Nearly all the different breeds of milch cows found in this country are represented in the herds; the Jerseys lead, and next in number come the Holsteins, Short Horns, Guernseys and Ayrshires, in the order given, with single representatives of the Brown-Swiss, Red Polled and Devon cattle.

Yield of milk and butter.—Referring to the comment on these figures on p. 87, we note that the average annual yields of milk and butter reported were 6,314 lbs. and 303 lbs. per head, respectively; 68 farmers reported their average yields of milk and 51 those of butter. The yields range from 3,000 to 12,000 lbs of milk, and from 165 to 497 lbs. of butter.

Average per cent. of fat in herd milk.—The average per cent. of fat in herd milk was reported by 54 farmers; the figures range between 3.5 and 6.0 per cent., with a general average of 4 59 per cent.

The farmers giving the average fat content of their herd milk were not always the same as those reporting the annual milk and butter product per cow, so that the average figures for these data are not directly comparable. In going over all the figures carefully it seems very likely that the average yield of butter reported is very nearly correct; while it may have been overestimated in some cases, in others no allowance was made for the milk consumed as such, so that the average may be considered about right, that is, a little more than 300 pounds of butter per year per cow.

This is a good average yield and may be considered a good standand. It has been exceeded by our dairymen only by a careful system of grading up their herds and weeding out poor cows, along with rich feeding and application of modern methods of creaming and churning. While our best dairymen do still better than this, exceeding

the average by one hundred, and in single instances by nearly two hundred pounds, the majority of dairy farmers do not reach it. The only way in which such a result can be reached, is by following the example set by men like those whose work is reported in the preceding pages: by a careful study of all conditions entering into the dairy business as factors, the kind of cows kept, the system of feeding, the making and sale of the products, etc.

Of late years it has come to be considered more and more essential to learn the value of each individual cow in the herd; for this a Babcock milk tester and a reliable pair of scales are indispensable, and also a looking into the feed account of each cow; the best cows are the ones that give the largest quantity of products at the least relative expense of food and labor, and neither they nor the poor cows in the herd can be found out except by a careful study of both food consumed and products obtained in each single case. This means opening up an account with each individual cow in the herd, in a measure in the same way as a store keeper keeps a special account with each customer.

Time during which cows go dry.—As will be learned by a glance at the tables, pp. 89–95, the practice followed by the majority of farmers in regard to the drying off of cows is to give them a rest of from one to two months previous to calving. Some farmers report that they cannot dry off their cows, or only with difficulty, but they are in the minority; the practice of milking up to the time of calving is strongly condemned by the best authorities; it impairs the constitutional strength of both mother and calf, and reduces the production of milk or butter during the subsequent lactation period.

The time when the cows are generally dried off, is governed by local conditions and business methods. If a farmer has a winter dairy, or supplies milk or cream to a creamery, he will dry off his cows in the latter part of the summer when dairy products are low; if he delivers milk or supplies butter to private customers he wants about the same quantity of milk the year around, and arranges it to have his cows come in at all seasons, etc.

Feeding stuffs used —The rations given on pp. 96–101, include three succulent feeds, eighteen coarse dry fodders, twenty seven concentrated feed stuffs, six kinds of roots and tubers, and one miscellaneous feed (skim milk), in all 56 different kinds of feeds; nearly two-thirds of the rations are made up of the twenty-two feeding stuffs given in the following list showing the number of times which the more important feeds appear in the rations; it will give a good idea of their relative economy and the favor in which they are held as winter feeds for dairy cows by our farmers.

Corn silage	64 times.	Corn meal	42 times.
Roots	13 times.	Corn and cob meal	14 times.
Corn fodder and stalks	35 times.	Wheat	8 times.
Mixed hay	42 times.	Oats	35 times.
Timothy hay	21 times	Barley	18 times.
Oat straw	16 times.	Linseed meal	37 times.
Clover hay	40 times.	Cotton seed meal	35 times.
Wheat bran	73 times	Pea meal	6 times.
Wheat shorts	13 times.	Malt sprouts	8 times.
Wheat middlings	11 times.	Gluten meal	8 times.

Nutrients fed in the various rations.—The tables on pp. 102–106, show the nutritive groups in the various rations, calculated per 1,000 lbs. live weight. As only a few rations were secured from some of the states, the average figures for each state do not offer reliable data for comparison. In the following table the states represented have been grouped in this manner.

***New England States.*—New Hampshire, Vermont, Massachusetts, Connecticut.**

***Middle States.*—New York, New Jersey, Pennsylvania, West Virginia.**

***Central States.*—Illinois, Indiana, Ohio, Kentucky, Iowa, Kansas, Nebraska.**

***North Central States.*—Wisconsin, Michigan, Minnesota, North Dakota.**

***Southern States.*—North Carolina, Texas.**

***Rocky Mountain States.*—Colorado, Utah.**

***Pacific States.*—Washington.**

Including the rations given in the tables referred to under these groups we have the following summary:

Nutrients in rations for dairy cows.

	No. of rations.	Organic matter.	Digestible Matter. Protein	Carb-hydr.	Fat.	Total.	Nutr. Ratio.
New England States..........	11	24.28	2.10	13.19	.75	16.04	1:7.1
Middle States..................	31	24.65	2.27	13.68	.82	16.77	1:6.8
Central States..	20	22.97	1.97	12.78	.72	15.47	1:7.3
North Central States..........	21	25.79	2.08	13.79	.68	16.55	1:7.3
Southern States.....	2	23.48	2.00	12.14	1.05	15.19	1:7.2
Rocky Mountain States.......	5	30.81	3.12	15.39	.79	19.30	1:5.5
Pacific States.................	1	21.60	2.68	10.54	.55	13.77	1:4.4
Canada.........................	9	21.57	1.76	11.69	.63	14.08	1:7.4

We notice here a general similarity in the make-up of the rations considered in the preceding pages; excluding the six rations from the Rocky Mountain states and Washington, the average rations vary only slightly, and practically not at all in the relation of nitrogenous to non-nitrogenons digestible constituents (nutritive ratio), which in all cases is about as 1:7. The rations, therefore, corroborate the results found by an examination of all data on this point available when published by the writer in the ninth annual report of this Station. Including the twenty-eight rations previously published, and combining the New England and Middle states, the Central and North Central states, the Rocky Mountain states and Washington, we have the following table of summary:

Summary of rations for dairy cows.

	No. of rations.	Organic matter.	Digestible Matter. Protein.	Carbh.	Fat.	Total.	Nutr. Ratio.
Eastern states.................	55	24.38	2.20	13.31	.77	16.28	1:6.8
Middle states.	56	24.64	2.08	13 37	.72	16.17	1:7 2
Southern states...............	2	23.48	2.00	12.14	1.05	15.19	1:7.2
Western states................	6	29.23	3.05	14.58	.75	18.38	1:5.8
Canada	9	21.57	1.76	11.69	.63	14.08	1:7.4

As will be seen, the average rations fed in the Eastern, Southern and Middle states are very nearly identical; the Canadian rations are all lighter rations than these (with but one exception), while the nutritive ratio is slightly wider. An examination of the table on p. 95 will suggest the reason for the light Canadian rations; eight out of the nine farmers reporting give breeding as their specialty of farming.

The western rations are greatly heavier and of a narrower nutritive ratio, owing to the large extent to which alfalfa enters into the rations. The number of rations secured from these states is too small, however, to allow of generalizations as to the system of feeding practiced there.

Combining all the above 128 rations which have been fed by successful dairy farmers and breeders in the various parts of our continent, we have the following average American ration, as it may be called, as against the rations published by German scientists, and heretofore largely used in this country.

American ration for dairy cows.

	Organic matter.	Digestible Matter.				Nutritive ratio.
		Protein.	Carbohydr.	Fat.	Total.	
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Average for 128 herds....	*24.51*	*2.15*	*13.27*	*.74*	*16.16*	*1:6.9*

This ration is practically the same as the one published in our Ninth Report; it is believed that it will be found correct for our American conditions, except perhaps for those of the Rocky mountains and the Pacific states. While local conditions or the business methods of farming in some sections may make a ration desirable which contains more protein than this, and has a narrower nutritive ratio as a consequence, we feel confident that in the large majority of cases its adoption will give satisfactory results, and that it is preferable to the German standard ration so long placed before our stock feeders as the ideal one, the nutri-

tive ratio of which is 1:5.4. It is the result of American feeding experience; the majority of our most successful dairymen feed in the way indicated by the ration, and we shall not go far amiss if we follow their example.

The practical importance in this matter lies in the fact that the nitrogenous feed stuffs are generally our most expensive foods; as the results published in the preceding bulletin plainly show, it will not as a rule be necessary to supply our cows with such quantities of them as to bring the proportion of nitrogenous to non-nitrogenous digestible components in their ration down to 1:5.4. Usually we shall not need to feed more than one-seventh as much of the former as we do of the latter; hence we can make up the rations to a large extent of feeds like corn fodder, corn silage, mixed hay, clover hay, corn, oats, pease, etc.; and need only supply the more expensive highly nitrogenous food in small quantities.

As regards the importance of rations and feeding standards in general, their uses and limitations, etc., the reader is referred to the discussions on the subject in this and previous reports from our Station. While we may be guided to some extent by their teachings, we must not be led blindly; the question of the proper kinds and classes of food stuffs to feed for any single purpose is one of practical economics and not one of physiological chemistry.

As the market prices of cattle foods and the local conditions vary to such a great extent with different regions, it is evident that no universal "best" ration for milch cows or for any other animals can be given. It is believed, however, that any dairy farmer can easily select a ration suited to his conditions from the abundant material given in the preceding pages.

ON THE COMPARATIVE FEEDING VALUE OF LINSEED MEAL, CORN MEAL AND WHEAT BRAN FOR MILCH COWS.

F. W. WOLL.

The question of the comparative value of linseed meal, corn meal and wheat bran is of a great deal of importance to Wisconsin dairymen. Large sums of money are paid out every year for concentrated feeds for the dairy herd; the question of which kind or kinds of feeds are the most economical is one frequently asked in letters to officers of our Station or in the agricultural press. As often explained in discussions of this subject in previous publications of this Station, there can be no set rule as to the relative value of cattle feeds, as this depends entirely on the combination in which the feeds to be compared are fed, and on the ends sought. Any data obtained in feeding experiments with different feeds will, however, be of value as showing their comparative effect under similar conditions and for similar purposes, as described in the experiments.

The experiment reported in the following pages was conducted at the University farm in 1893; twelve cows separated into three even lots were included in the experiment. The experiment was divided into three periods of four weeks each. All cows received throughout the experiment a basal ration consisting of eight pounds of oat hay, four pounds of shorts, and yellow dent corn silage *ad libitum*. In addition the cows in the three lots received oilmeal, corn meal and bran during the different periods as follows:

	Lot A.	*Lot B.*	*Lot C.*
Period I	Oil meal.	Corn meal.	Wheat bran.
Period II	Corn meal.	Wheat bran.	Oil meal.
Period III	Oil meal.	Corn meal.	Wheat bran.

The quantities of grain feeds given, exclusive of shorts, varied according to the capacity of the different cows, one cow in each lot receiving five pounds, two receiving four pounds, and one three pounds per day. Each cow was given the same quantity of oil meal and corn meal, or corn meal and bran, or bran and oil meal, during the different periods of the experiment.

The following is a list of the cows included on the experiment, with information concerning their breed, age, dates of calving and service:

List of cows on the experiment.

Lot.	Name.	Breed.	Approximate age.	Calved.	Served.
I.	Beauty	Native	12 years	Sept. 10, '92	Dec. 22
					Jan. 24
	Palmera	Grade Jersey	4 years	Nov. 5	Dec. 20
	Sylvan	High grade Jersey	5 years	Oct. 4	Dec. 16
	Bessie Heifer	High grade Jersey	5 years	Sept. 25	Dec. 28
II.	Emma	Grade Jersey	11 years	Sept. 30	Dec. 21
	Bunn	Holstein-Jersey	9 years	Oct. 26	Dec. 31
	Daisy	Grade Jersey	11 years	Dec 21	Jan. 30
	Rue*	Reg. Jersey	8-9 years	Oct. 9	Jan. 25
III.	Bryant	High grade Jersey	4 years	Nov. 7	Dec. 17
	Doubtful	High grade Jersey	4 years	May 16	Jan. 17
	Galena	High grade Jersey	9 years	Sept. 9	Jan. 19
	Daisy Heifer	High grade Jersey	6½ years	Oct. 6	Dec. 29

The preliminary feeding on the experiment began December 27th, 1892; the experiment proper began January 2d, 1893, and ended April 6th; one week of preliminary feeding introduced each period; during these intermediate weeks the milk and food were weighed as usual, but the data obtained during these weeks are not included in the total results for each feed. The milk of each individual cow from each milking was weighed, sampled and analyzed separately. The sampling took place during the

first and fourth weeks of each period, when the cows were also weighed daily, and the quantity of water drank by each ascertained. The cows were milked twice a day by the same farm hands throughout the experiment, and in the same order, the milking beginning at 5 P. M. and 5 A. M. sharp. The fat content and the specific gravity of each sample of milk were determined; the nitrogen and the ash contents of the milk were determined twice a week in composite samples of the morning and evening milk from each cow. Microscopic examinations of the mixed milk from each lot were further made on the first five days of the first and the fourth week of each period. The corn silage fed on the experiment was sampled once a week, and the grain fed and oat hay each week when the milk was analyzed, the sampling in all cases taking place at regular intervals.

The experiment progressed without any accident of any kind after the first week; one of the cows of the experiment lost her appetite during this week, and as a result yielded very poorly; it was, therefore, considered best to change at once, and the cow Daisy given in the preceding list of cows was included on the experiment in her place.

The Fodders Fed.—The corn silage fed on the experiment was from the Station circular silo, and was made from Pride of the North yellow dent corn; the silo was filled September 8th, 1892, and opened December 8th. The corn was mostly dented at the time of cutting, and was in good condition. The silage was of a very good quality.

The wheat shorts and bran were bought from the local roller mills. The oat hay was grown on the University farm; it was cut when the kernels were in the milk and cured in an exceedingly fine condition; the yield obtained was at the rate of about three tons per acre.

The corn meal was from Iowa corn, and was bought in a carload lot.

The linseed meal was from the Mankato Linseed Oil Co., Mankato, Minn., and was new process oil meal.

Order of Feeding.—Hay was fed first in the morning (at 4:45 A. M.), and in the afternoon (about 3 P. M); after breakfast grain was fed, being mixed with hay if any was left over; silage was then fed. In the afternoon grain was fed at about 4 o'clock, and silage a little before 5. Watering and weighing of the cows took place at 9 A. M. Feed boxes were cleaned out and residues that might be found weighed back between 10 and 11 A. M.

The cows were not let out during the whole experiment; they were kept in Bidwell box stalls and seemed perfectly comfortable all the time. When let out at the close of the experiment they acted in no way so as to indicate that the confinement had injured them.

RATIONS FED AND DRY MATTER CONSUMED.

The following average quantities of feeding stuffs were fed during the first and the fourth weeks of the different periods; the silage was fed *ad libitum*, the small quantities of refuse oat hay and silage are deducted from the total amounts weighed out and the difference averaged per day.

Average rations eaten per head, in pounds.

	Corn silage.	Oat hay.	Wheat shorts.	Oilmeal.	Cornmeal.	Wheat bran.
LOT A.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Period I	39.4	7.9	4 0	3.5	....	....
Period II	39.1	7.9	4.0	....	4 25	....
Period III	42.2	7.7	4.0	4.25	....	....
LOT B.						
Period I	39.7	7.8	4.0	....	4.0	....
Period II	42.2	7.8	4.0	....	....	4.0
Period III	46.3	7.8	4.0	....	4.0	....
LOT C.						
Period I	38.1	8.0	4.0	....	....	3.5
Period II	42.2	8.0	4 0	4.25	....	....
Period III	40.6	7.9	4.0	....	....	4.25

The quantities of dry matter consumed during the different periods are given below, the amounts consumed by the different lots during the weeks when the milk was sampled and analyzed being first given, and those consumed during the whole experiment being given in the latter half of the table.

Total dry matter consumed, in pounds.

	Period I.	Period II	Period III.
Total for six weeks—			
Lot A	1468.9	1420.6	1458.3
Lot B	1491.0	1491.0	1507.1
Lot C	1523.7	1590.4	1504.8
Total for whole experiment—			
Lot A	3025.8	2974.5	3035.3
Lot B	3099.0	3110.2	3128.2
Lot C	3182.0	3327.5	3145.9

Since each period contained the equivalent of 112 days for one cow, the average daily quantities of dry matter consumed by the different lots during each period were as follows: Lot A, 27.02 lbs., 26.56 lbs. and 27.06 lbs., for periods I, II and III, respectively; for Lot B, 27.68 lbs., 27.77 lbs. and 27.81 lbs.; and for Lot C, 28.41 lbs., 29.72 lbs. and 28.26 lbs.

Average Rations Fed.—The following average rations were fed to the cows in the different lots during the whole experiment:

On *oil meal*, 40.9 lbs. silage, 7.8 lbs. hay, 4.2 lbs. oil meal, and 4.0 lbs. shorts.

On *corn meal*, 39.6 lbs. silage, 7.8 lbs. hay, 4.1 lbs. corn meal, and 4.0 lbs. shorts.

On *wheat bran*, 41.6 lbs. silage, 7.9 lbs. hay, 4.1 lbs. wheat bran, and 4.0 lbs. shorts.

Owing to pressure of other work the feeding stuffs fed were not analyzed beyond ascertaining the dry matter and

protein contained in them. If the other components are assumed according to the average composition of each food stuff and ordinary digestion coefficients are taken for the constituents, we find that these rations contain the following quantities of organic matter and digestible components:

	Oil meal ration.	Corn meal ration.	Wheat bran ration.
	lbs.	lbs.	lbs.
Organic matter	25.45	25.09	25.58
Digestible protein	2.68	1.71	1.97
Digestible carbohydrates	13.72	14.68	14.32
Digestible fat	.89	.75	.72
Total digestible matter	17.24	17.14	17.01
Nutritive ratio	1: 6.0	1: 9.5	1: 8.1

LIVE WEIGHT AND WATER DRANK.

All cows gained in live weight during the experiment, viz.: from 6 pounds to 79 pounds a head; the average live weight of all cows during the first week of period I was 912 pounds, and during the last week of period III 949 pounds, or an average gain per cow of 37 pounds in 88 days. The following table shows the average live weights of the cows and the quantity of water drank during the different periods of the experiment:

Average live weights and quantities of water drank.

NAMES OF COWS.	LIVE WEIGHT, LBS.			WATER DRANK, LBS.		
	Period I.	Period II.	Period III.	Period I.	Period II.	Period III.
Beauty	1,119	1,132	1,143	77.0	59.1	59.6
Palmera..........	852	851	858	67.0	54.3	49.9
Sylvan.......	754	803	816	61.7	43.6	55.4
Bessie 2nd	885	892	897	75.7	64.3	72.6
Averages.....	910	920	929	70.4	55.3	61.9
Emma.....	859	875	887	57.0	56.8	53.9
Bunn.....	1,168	1,201	1,202	77.9	73.0	67.6
Daisy.............	746	752	760	52.1	66.3	66.7
Rue..............	919	929	949	63.4	58.9	55.2
Averages.....	923	939	950	62.6	63.8	60.9
Bryant	879	888	907	63.4	61.4	57.7
Doubtful...... ...	934	968	993	69.9	69.7	69.4
Galena	1,011	1,030	1,022	72.5	72.1	68.7
Daisy 2nd	868	899	911	67.4	65.2	61.3
Averages.....	923	946	958	68.3	67.1	64.3

If the averages for periods I and III for each lot are compared with the figures obtained during the second period in each case, we find that the latter were higher or lower than the former as shown below:

	Lot A.	Lot B.	Lot C.
Live weight, lbs	+ 0 lbs.	+ 2 lbs.	+ 5 lbs.
Water drank, lbs..............................	— 6.1 lbs.	+ 2.0 lbs.	+ .8 lbs.

These figures show the influence of the different concentrated feed stuffs on the live weight and the water drank by the animals; there is an increase in weight on the wheat bran feeding over the corn meal, and on oil meal over wheat bran; the water drank is lower on corn meal than on oil meal, higher on bran than on corn meal, and somewhat higher on oil meal than on bran. This will be more

apparent if we collect the average figures for all three lots with each feed:

	Oil Meal.	Corn Meal.	Wheat Bran.
Live weight, lbs	928 0	931.0	940.0
Water drank, lbs	66.5	59.6	65.5

The lots of cows were very even, so that the preceding figures, although each an average for only 8 cows, may be safely compared with one another; they show that there was a gain in live weight on corn meal and on wheat bran over the weight of the cows while on oil meal; as regards the water drank, the figures show that the cows drank most water while on oil meal, less while on wheat bran, and least while on corn meal. This is in accordance with well known physiological laws and with general experience, which teaches us that the feeding of nitrogenous rations is always accompanied by an increased consumption of water and an increased excretion of urea and of urine.

EFFECT OF FOOD ON COMPOSITION OF MILK.

The average composition of milk produced by each cow during different periods is shown in the following table:

Average Percentage Composition of Milk.

Names of Cows.	Period I.—Oil Meal.				Period II.—Corn Meal.				Period III.—Oil Meal.			
	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.
Beauty	9.56	3.86	3.52	.73	9.58	3.75	3.75	.72	9.58	4.28	3.45	.71
Palmera	9.31	4.78	3 40	.83	9.60	5.02	3.48	.85	9.55	5.39	3.43	.83
Sylvan	10.11	5.92	3 88	.81	10.31	5.98	3.88	.79	10.04	6.32	3.89	.79
Bessie 2nd	9.82	5.41	3.66	.83	9.88	5.38	3.63	.82	9.66	5.78	3.59	.81
Av. for Lot A	9.70	4.99	3.62	.80	9.84	5.08	3 69	.80	9.71	5.44	3.59	.79

NAMES OF COWS.	PERIOD I.—CORN MEAL.				PERIOD II.—WHEAT BRAN.				PERIOD III.—CORN MEAL.			
	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.
Emma	9.66	4.58	3.62	.80	9.74	5.06	3.66	.83	9.73	5.20	3.57	.78
Bunn	8.62	2.91	2.59	.74	8.60	3.09	2.87	.73	8.50	3.15	2 42	.73
Daisy	9.63	4.59	3.22	.74	9.74	4 79	3.59	.75	9.64	4.92	3.08	.75
Rue	10.06	5.34	3.89	.88	10 06	5.62	3.78	.89	10.00	5.69	3 83	.86
Av. for Lot B	9.49	4.36	3.33	.79	9.54	4.64	3.48	.80	9.47	4.74	3.23	.78

NAMES OF COWS.	PERIOD I.—WHEAT BRAN.				PERIOD II.—OIL MEAL.				PERIOD III.—WHEAT BRAN.			
	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.	Solids not fat.	Fat.	Casein and albumen.	Ash.
Bryant	9.67	4.50	3.20	.79	9.84	4.69	3.30	.78	9.71	5.10	3.15	.75
Doubtful	9.98	6.07	3.86	.82	9.80	5 56	4.08	.79	9.74	6.07	3.62	.80
Galena	10.00	5.34	3.50	.72	9 88	5.40	3.36	.75	9.88	5.72	3.30	.71
Daisy 2nd	9.76	4 96	3.44	.76	9.85	5.11	3.47	.79	9.64	5.51	3.30	.77
Av. for Lot C	9.85	5.22	3.50	.77	9.84	5.19	3.55	.78	9.74	5.60	3.34	.76

The preceding averages are the arithmetical means of the data for each set of four cows and do not take into account the quantity of milk yielded by the different animals.

In changing the food from oil meal to corn meal in case of lot A the per cent. of fat in the milk from two cows was decreased and in that of two other cows increased; when the opposite change was made the per cent. of fat increased, on the average from .30 to .53 per cent.

In changing the food from corn meal to bran in case of lot B the per cent. of fat in the milk from all four cows increased; when the opposite change was made there was also an increase in per cent. of fat, on the average from .06 to .23 per cent.

In changing the food from bran to oil meal in case of lot C the milk from three cows became richer in fat and that from the fourth cow became poorer; when the opposite change was made the milk from all the cows became richer, from .32 to .51 per cent. on the average for the whole periods.

If the average data for periods I and III in the preceding table be compared with those of period II we find that the influence of the substitution of corn meal, bran and oil meal in the rations of the three lots may be traced as shown in the following statement, the percentage of solids not fat, fat, casein and albumen, and ash being higher or lower during the second period that the average of the two other periods according to the sign affixed.

	Solids not fat.	Fat.	Casein &c.	Ash.
Corn Meal	+ .14	—.19	+ .08	+ .01
Wheat Bran	+ .06	+.09	+ .20	+ .01
Oil Meal	+ .04	—.22	+ .13	+ .01

The changes in the per cent. of fat shows unanimously in the direction indicated in case of all four cows in the different lots; with the other constituents there is less unanimity and a less decided change.

We find on the average that corn meal produced milk containing a lower percentage of fat and solids, and a higher per cent. of solids not fat than did oil meal; and produced a milk containing a lower per cent. of solids, solids not fat, and fat than did wheat bran; wheat bran produced milk containing a higher percentage of solids and fat, and a lower per cent. of solids not fat than did oil meal.

EFFECT OF FOOD ON YIELD OF MILK AND FAT.

The quantities of milk and fat produced by the different cows during the different periods are given in the following table, as are also the quantities of silage eaten by the

cows. The data include the production during the first and fourth weeks of each period.

Silage eaten and yield of milk and fat in pounds.

	Silage eaten.	PERIOD I—OIL MEAL.		Silage eaten.	PERIOD II—CORN MEAL.		Silage eaten.	PERIOD III—OIL MEAL.	
		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.
Beauty	634.0	266.9	10.29	546.0	227.8	8.54	576.5	212.4	9.10
Palmera	528.8	269.5	12.88	479.0	208.0	10.43	496.5	186.9	10.08
Sylvan	434.5	160.7	9.52	435.8	133.5	7.98	416.5	126.5	8.05
Bessie 2nd ...	611.3	266.8	14.42	664.3	242.1	13.02	646.0	236.0	13.65
Total Lot A	2208.6	963.9	47.11	2125.1	811.4	39.97	2135.5	761.8	40.88

	Silage eaten.	PERIOD I—CORN MEAL.		Silage eaten.	PERIOD II—WHEAT BRAN.		Silage eaten.	PERIOD III—CORN MEAL.	
		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.
Emma	503.3	189.5	3.68	542.8	156.5	7.91	481.0	152.1	7.91
Bunn	743.5	387.4	11.27	782.8	331.9	10.22	724.8	288.5	9.10
Daisy	374.8	216.2	9.52	463.0	299.9	14.85	535.0	297.3	14.63
Rue	571.0	233.2	12.46	575.5	204.2	11.48	620.0	202.9	11.55
Total Lot B	2195.6	1026.3	41.93	2364.1	992.5	43.96	2360.8	940.8	43.19

	Silage eaten.	PERIOD I—WHEAT BRAN.		Silage eaten.	PERIOD II—OIL MEAL.		Silage eaten.	PERIOD III—WHEAT BRAN.	
		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.		Yield of milk	Yield of fat.
Bryant	537.2	236.5	10.64	599.5	241.8	11.34	520.5	207.4	10.57
Doubtful ...	545.8	159.7	9.66	654.0	156.1	8.68	594.5	144.2	8.75
Galena	635.0	304.3	16.24	592.0	290.7	15.75	568.0	252.2	14.42
Daisy 2nd ...	642.8	274.0	13.58	744.5	265.7	13.58	592.0	227.5	12.53
Total Lot C	2360.8	974.5	50.12	2590.0	954.3	49.35	2275.0	831.3	46.27

In discussing these figures we shall only consider the average data for each lot. If the averages for periods I and III are calculated and comparisons made with the second period, we find in the case of the different lots:

	Yield of Milk.	Yield of Fat.	Per cent. fat.
	lbs.	lbs.	lbs.
Lot A—			
Averages for oil meal periods	862.9	44.00	5.10
Higher for oil meal than for corn meal	51.5	4.08	.17
In per cent	*6.0*	*.9*	*.17*
Lot B—			
Averages for corn meal periods	983 6	42.56	4.33
Higher for wheat bran than for corn meal	8.9	1.40	.10
In per cent	*.9*	*3.3*	*.10*
Lot C—			
Averages for wheat bran periods	902.9	48.20	5.34
Higher for oil meal than for bran	51.4	1.15	.17
In per cent	*5.7*	*2.4*	*.17*

These results do not show any material difference in the influence of the three concentrated feeds on the production of milk and fat under the conditions present in this experiment. Oil meal gives a slightly better result than corn meal or wheat bran, and the latter two feeds give practically the same results, the main difference lying in the somewhat higher fat content of the milk on the bran feeding.

If the data for each feed are summarized, we find the total quantities of products yielded by eight cows during three different periods; while not directly comparable, the figures may be taken to express approximately the relative efficiency of the feeds under the conditions given; we then obtain the following statement:

Concentrated Feed.	Silage eaten	Yield of Milk.	Yield of Fat.	Per cent. fat.
	lbs.	lbs.	lbs.	
Oil meal	6934.0	2680.0	137.34	5.13
Corn meal	6677.7	2778.5	125.9	4.50
Wheat bran	7000.0	2798.3	140.35	5.01
Increased yield on *Corn meal* over *Oil meal*, per cent		*3.7*	*—9.8*	*—.63*
Increased yield on *Wheat bran* over *Oil meal*, per cent		*4.4*	*2.2*	*—.12*
Increased yield on *Wheat bran* over *Corn meal*, per cent		*7.*	*12.0*	*+.51*

The figures given in the preceding table may be taken to represent, in a general way, the differences obtained from the feeding of the three concentrated feeds under the conditions given.

Yield of Milk During the Whole Experiment.—As stated in the introduction, the milk produced by the cows on the experiment was sampled and analyzed during the first and the fourth weeks of each period; the weights of silage eaten and of milk produced was ascertained throughout the experiment. The data have been summarized, and similar calculations made as given in the preceding table, with results leading to exactly the same conclusions as those already determined from the data obtained during the weeks when the milk was analyzed. For this reason we shall not here go over the same ground with the results for the whole experiment, but shall only give the total quantities of silage consumed during the different periods when different concentrated foods were fed:

Results for whole experiment, in pounds.

	Period I.		Period II.		Period III.	
	Silage eaten	Milk yield	Silage eaten	Milk yield	Silage eaten	Milk yield
Lot A..............	4300.7	1891.6	4188.0	1615.5	4280.8	1518.9
Lot B	4433.5	2100.5	4655.4	1987.7	4678.7	1877.9
Lot C	4747.6	1932.8	5159.1	1903.9	4598.6	1657.6
Total for Oil meal periods.......					13740.6	5314.4
Total for Corn Meal periods...					13301.3	5593.9
Total for Wheat Bran periods.					14001.5	5578.1

The total results show that about *five* per cent. more milk was produced on corn meal and on bran, than on oil meal, with the yield on corn meal and on bran practically the same.

PRODUCTION OF MILK AND FAT FOR 100 POUNDS OF DRY MATTER.

By comparing the data given in the first part of the preceding table with the total yield of milk and fat during the corresponding weeks we are able to refer the production of milk and fat to a unit of 100 pounds of dry matter consumed. In the following table the data thus obtained may be seen:

100 lbs. of dry matter produced.

	Lot A.			Lot B.			Lot C.		
	Oil meal	Corn meal	Oil meal	Corn meal	Bran	Corn meal	Bran	Oil meal	Corn meal
Milk, lbs.........	65.5	51.7	52.2	69.3	66.6	62.4	64 0	60.0	55.3
Av. of I and III	....	....	58.85	......	....	65.85	....	....	59.65
Diff'ce, per ct..	....	*−3*	....	......	*+1*	....	.....	*−.5*	....
Milk Fat, lbs ...	3.20	2.81	2.80	2.83	2 95	2.87	3.27	3.10	3.08
Av. of I and III	....	....	3.00	....	......	2.85	.....	....	3.165
Diff'ce, per ct..	....	*−7*	....	....	*+3*	......	......	*−2*	.....

If similar calculations are made on basis of dry matter consumed and milk produced by all cows during the whole experiment similar results are obtained, the difference between the mean of the first and the third periods, and the second periods amounting to —3, —1, and +1 per cent., in case of lot A, B, and C, respectively.

Grouping the data obtained during the six weeks of the experiment when the milk was analyzed, according to the concentrated foods fed, we have the following statement for each kind of food:

	Oil meal.	Corn meal.	Wheat bran.
Total dry matter eaten by four cows during six weeks, lbs.	4517.6	4408.7	4519.5
100 lbs. dry matter produced—			
Milk, lbs	59.3	63.0	61.9
Fat, lbs	3.04	2.84	3.11

Increase on oil meal over corn meal.............................7 per cent. in yield of fat.
Increase on corn meal over oil meal ... .6 per cent. in yield of milk.
Increase on corn meal over wheat bran...................... .. 2 per cent. in yield of milk.
Increase on wheat bran over oil meal... ....4 per cent. in yield of milk.
Increase on wheat bran over oil meal...... ....2 per cent. in yield of fat.
Increase on wheat bran over corn meal........... .... 9 per cent in yield of fat.

MICROSCOPIC EXAMINATION OF MILK.

As before stated the milk from the different lots was examined microscopically during the first five days of the first and the fourth weeks of each period. It will be sufficient to give here the average data for each lot and period, as these will show in how far conclusions drawn are justified.

Results of microscopic examinations.

AVERAGES FOR EACH PERIOD	LOT A. Oil meal—Corn meal.		LOT B. Corn meal—Wheat bran.		LOT C. Wheat bran—Oil meal.	
	Globules in .0001 cmm.	Relative size.	Globules in .0001 cmm.	Relative size.	Globules in .0001 cmm.	Relative size.
Period I.	189	263	145	292	154	339
Period III.	212	261	163	276	179	295
Averages for oil meal, corn meal, and wheat bran periods, respectively..........	200	262	154	284	167	317
Period II	193	262	144	308	148	356
Difference between Period I & III, and II...............	–7	0	–10	+24	–19	+ 39

The results would indicate that both wheat bran and oil meal have a tendency to increase the size of the fat globules in cow's milk, a conclusion which is corroborated by the small amount of work previously done in this line.*

DISCUSSION OF RESULTS.

The data given in the preceding pages show that under the conditions present in this experiment there was practically no difference in the immediate effect of the corn meal and the wheat bran on the yield of the milk, and that there was a small difference in favor of the oil meal; as regards the production of fat both oil meal and bran give better results than corn meal, neither of these differences being, however, very marked.

The plan of the experiment precludes a study of the effect of these foods beyond the time when they were fed (the residuary effect). Experiments made during late years both in this country and abroad show that the influence of the food as to the productive capacity of animals may be extended much further than the time during which

*Agricultural Science, VI, 520.

it is being fed. In feeding experiments at Cornell University* the cows receiving grain while on pasture gave more milk during six months following the period of lactation than cows in the same herd receiving no grain, the conditions of both lots of cows being strictly conformable.

In Danish feeding experiments it was noticed that different lots of cows originally perfectly even in milk yield, produced more milk during the later stages of the lactation period the richer the rations fed during the experiment were.†

Ramm‡ made similar observations and showed that it is possible to keep up the high production of milk and fat until toward the end of the lactation period by feeding ample and highly nutritious food, especially during the former part of the same.

It is possible that the feeds fed in these experiments would have shown some difference in their residuary effect on the milk yield, but it is not likely that such would be the case, since whenever such an influence has been observable the immediate effect has been marked, and even more so than the residuary one. The former being but slightly marked in this experiment we may be justified in concluding that the latter would be still less so and therefore too small to require consideration. We are then brought back to look at the effects observed during the course of the experiment from the view of ordinary practical conditions.

The average Wisconsin prices for the three concentrated food compared are as follows: oil meal $24 per ton, corn meal $15 per ton and wheat bran $13 per ton. The discussions entered upon in the preceding will show that under the conditions present the wheat bran was by far the more economical food, since it cost less and produced more, or nearly as much milk or fat as either of the other feeds. The comparison comes out most unfavorable to the oil meal and allows of but one conclusion, namely, that given a good, fairly nitrogenous basal

* Bulletin 49, Cornell University Experiment Station.

† 27th Report Copenhagen Experiment Station; Experiment Station Record, IV, 601.

‡ Landw. Jahrb. 21 (1892), 810.

ration an addition of wheat bran or corn meal at the prices stated is in the line of economy rather than feeding oil meal.

Previous work in this line at this Station by Dr. H. P. Armsby led to the same conclusion, although the results obtained were hardly as decisive as in the present case.* In experiments with the three feeds given conducted at this or other stations† no appreciable difference in the relative value of the feeds have been found, and the teachings of these experiments are, therefore, in the line of previous experience.

While the evidence on hand goes to prove that oil meal does not possess the value which would naturally be ascribed to it from its high content of digestible protein, or from its cost in our section, and cannot for this reason be fed to advantage in large quantities under our conditions, its dietetic value is of importance; it will furthermore furnish variety to a ration and make it more palatable. Oil meal, therefore, has a place to fill in our system of feeding dairy cows, but under ordinary Wisconsin conditions it should only be fed in small quantities, the bulk of the concentrated feed being made up of the relatively cheaper grain foods or of the refuse products from the same.

* Report III, p. 97; Report IV, p. 130.

† Colorado Expt. Sta., Bulletin 20. Pa. Expt. Sta., Report for 1891. Wis. Expt. Sta., Reports III and IV.

EXPERIMENTS IN THE MANUFACTURE OF CHEESE.

S. M. BABCOCK.

Nearly all of the investigations upon cheese made at this Station have been in connection with the Dairy School, the amount of milk available from the Station herd being too small to admit of extended experiments at other times. Most of the work has been done by students under the direct supervision of an instructor. From the data thus secured, during the past four winters, a few lines of work, in which practically uniform results have been obtained, are selected for this report. These will be presented under the following heads, viz.:

1. The influence of fat upon the yield of cheese.
2. The influence of fat upon the quality of cheese.
3. The yield of cheese from different qualities of milk, and at different seasons of the year, in factories.
4. The loss of weight in the curing of cheese.
5. Cleaning milk for cheese with a centrifugal machine.

1. THE INFLUENCE OF FAT UPON THE YIELD OF CHEESE.

Experiments bearing upon this question were commenced in the winter term 1891 and have been continued each year since. The experiments have been conducted by dividing a lot of mixed milk into two parts, from one of which a portion or all of the cream was removed by a centrifugal cream separator. Sometimes a portion of the cream thus obtained from one part was added to the other part, making it abnormally rich. These two milks have been made into cheese by the cheddar process, the same conditions being maintained so far as practical in each case. The yield of cheese from the two

lots of milk have been reduced to yields per 100 lbs. of milk and the difference has been attributed to the difference in the per cents. of fat, or what is the same thing, to the number of pounds of fat which 100 lbs. of the richer milks contained in excess of that in 100 lbs. of the poorer milk. A correction is afterwards made for the slightly larger amount of milk serum, that is milk from which all the fat has been removed, in the poorer milks.

The following example will show how the calculations have been made:

No of vat.	Lbs. of milk.	Per cent. of fat.	Yield of cheese.	For 100 Lbs. of Milk.	
				Lbs. of fat.	Yield of cheese.
1.	402	4.85	44.	4.85	10.94
2.	425	3.00	37.75	3.00	8.88
Difference for 100 lbs. milk....	....	....	....	1.85	2.06
Increase for one pound of fat					1.11 lbs. cheese.

This method of computation shows the practical effect upon the yield of cheese of each pound of fat removed from milk by skimming or added to milk in the form of cream, it being assumed in all such cases that the composition of the milk serum remains unchanged.

The average result obtained in this way in seventy trials, in which the fat, in the milks compared, differed by one or more per cent., gives 1.07 pounds of green cheese as the apparent yield of one pound of fat. The range was from .81 lbs. to 1.52 lbs., but most of the trials gave figures which were near the average.

The actual amount of green cheese which one pound of fat in these milks has contributed is greater than this by the amount of cheese made from one pound of milk serum. This is evident because one pound of serum in the poorer milk has replaced each pound of fat removed from the rich milk, and in the calculation the cheese produced from the serum has been subtracted from the yield of the rich milk. In these experiments each pound of serum has yielded a little less than

.06 lbs. of green cheese which added to 1.07, the apparent yield from one pound of fat, gives 1.13 as the actual amount of cheese produced from one pound of fat, which is approximately the same as the yield of butter from the same amount of fat. As only about nine-tenths of the fat in the milk is recovered in the cheese it follows that nine-tenths of a pound of fat holds mechanically in the green cheese a little more than two-tenths pounds of whey, which is very nearly the same relation that exists in butter between the butter fat and the other constituents.

In general it may be stated that one pound of fat in milk will produce about 1.1 lb. of green cheese. The milk used in these experiments contained an average of 2.5 per cent. of fat and yielded an average of 8.63 lbs. of cheese from 100 lbs. of milk. Giving the value just mentioned to the fat in these milks and there remains an average of 5.88 lbs. of green cheese from each 100 lbs. of milk which must have been derived from the 97.5 lbs. of serum. This is at the rate of .06 lb. of cheese for each pound of serum.

The one constituent of the serum that is essential to the production of cheese is caseine, which when coagulated by rennet holds mechanically a considerable amount of whey. Dr. L. L. Van Slyke* has found that factory milk contains on the average 2.46 per cent. of caseine. It is probable that the milks used in these tests contained a little less than this as they were all produced early in the season when the caseine is usually less than the average. If it is assumed that the milk serum in these tests contained an average of 2.4 per cent. caseine then the yield of green cheese (6 lbs. from each 100 lbs. of serum) is two and one half times the casein. That is each pound of casein in milk will produce on the average two and one-half pounds of green cheese, one and one-half pounds of which is whey held mechanically in the curd.

Applying these values to fat and casein leads to the following rule for calculating the yield of green cheddar cheese from the composition of milk. The yield of green cheddar cheese from 100 lbs. of milk is equal to 1.1 times the per

* 12th Annual Report N. Y. Agr. Expt. Station, p. 358.

cent. of fat added to 2.5 times the per cent. casein in the milk. This rule was suggested by the writer to Dr. Van Slyke* nearly two years ago and it has been used by him in all of his cheese work since, with most satisfactory results.

The rule is applicable to all milks even when they are watered, skimmed or enriched by adding cream.

The yield of green cheese from 100 lbs. of milk may be roughly estimated without a complete analysis of the milk, by adding 5.9 to 1.1 times the per cent. of fat in the milk. The cured cheese thirty days old may be found approximately by adding 5.7 instead of 5.9 to 1.1 times the per cent. of fat. This last rule does not apply to watered milk, it also will vary some with the season of the year and with the per cent. of fat in the milk.

2. INFLUENCE OF FAT ON THE QUALITY OF CHEESE.

In March, 1891, a number of cheese were made to determine the relation which the quality of the cheese measured by the price it sells for in the open market has to the fat in the milk. As it was impracticable to obtain a sufficient quantity of very rich milk for these tests the end desired was reached by dividing a quantity of mixed milk and adding cream removed from one portion, to the other. In this way two vats of milk were obtained in which there was a difference of two or more per cent. in the amount of fat, both of which were made into cheese by the same method and, so far as practicable, under the same conditions. The cheese were kept until October when they were between six and seven months old and were then sent to a disinterested party in Chicago who invited in a number of prominent cheese dealers of that city and asked their opinion regarding the value of the different cheese. None of the persons who examined these cheese knew where they were from or the conditions under which they were made, nor did they know what the judgment of the other parties had been regarding the quality. Owing to the wide variation in the values put upon the cheese by different buyers, the result of the trial was very unsatisfactory and

*12th Annual Report N. Y. Agr Expt. Station, p. 470.

only served to show that this plan of fixing values cannot be depended upon. This will be evident to the reader when it is stated that the prices, put by different buyers upon one of these cheese, ranged from five to fifteen cents per pound, while one buyer declined to put any price upon it, saying it had no market value. At this time the wholesale price of factory cheese in Chicago was from 10 to 11 cents per pound. In general it may be said that the cheese made from the richer milk was valued one or two cents per pound higher than that made from the poorer milk. In two cases there was enough rich milk to make two cheese weighing about 60 lbs. each, only one of which was scored by the judges. The extra cheese were sold to a retail grocer for 15 cents per pound and were sold by him to customers at 20 cents per pound. We could have sold tons of such cheese at the same rate; one grocer in Chicago would have taken a large quantity and a number of requests were received from individuals for cheese of this kind. It may be said in explanation of the varied judgments of the Chicago buyers, that these cheese belonged to a different class from that in which they were accustomed to deal. They were old cheese in which the casein was entirely broken down, giving them a softer texture and a more pronounced flavor than is found in factory cheese thirty days old which make up a large part of the wholesale trade. At the same time the flavor of the cheese was not unpleasantly strong and they had none of the sharp biting flavor so common in cheese of this age. Evidently the wholesale dealers judged them from the factory standpoint, while the retail grocers recognized in them qualities closely allied to some of the high priced foreign cheese and fixed their value accordingly.

In the following table is given the per cent. of fat in the milk used in each trial, the loss of fat in the process of manufacture and the weight of cheese when taken from the press, and when sent to Chicago. The cheese made on the same day, differing only in the amount of fat which the milk contained, are put together so that they may be readily compared. Quantities given are in every case for 100 lbs. of milk.

Table showing yield of cheese and loss of fat from 100 *pounds of milk.*

No.	Date 1891.	Per cent. of fat in milk.	Per cent. of fat in whey.	Total loss of fat in whey and press drainings.	Weight of cheese.		Per cent. of fat in cheese (calculated).
					Green.	Cured.	
				Lbs.	Lbs.	Lbs.	
1	March 27.	2.70	.25	.27	8.375	7.53	32.3
2	March 27..	4.35	.40	.398	10.550	9.50	41.6
3	March 28..	2.90	.28	.268	8.823	8.00	32.7
4	March 28..	4.55	.40	.379	10.708	9 77	42.6
5	March 30..	3.15	.32	.295	8.937	8.00	35.4
6	March 30..	6.20	.59	.5·3	12.500	11.14	50.4
7	March 31..	3.00	.37	529	8.882	8.06	30.6
8	March 31..	4.85	.46	.635	10.936	9.99	42.2

The milks used on March 30th and 31st were overripe, which in a measure accounts for the losses being larger on these days than on the others. One cheese expert who examined these cheese a day or two before they were sent to Chicago, without being informed how the cheese were made, gave judgment regarding their value that is quite consistent with the prices actually obtained. These prices are given in the following table together with the weights of cured cheese and the value of a pound of fat in the milk from which the cheese was made.

Table showing the value of fat in cheese made from milk of different composition.

No. of cheese.	Per cent. of fat in milk.	Yield of cured cheese from 100 lbs. of milk.	Price per lb.	Value of cheese.	Price per lb. of fat in milk.	Value of added fat per lb.
			Cents.	Cents.		
1................	2 70	7.53	8.	60.21	22 3	
2........	4.35	9.50	12.5	118.75	27 3	35.4
3................	2.90	8.00	8.	64 00	22.1	
4....	4.55	9.77	12.5	122.12	26 9	35.2
5.	3.15	8.00	8.	64.00	20.3	
6.	6.20	11.14	12 5	139.25	22.4	24 6
7................	3.00	8.06	8.5	68.51	22.8	
8.	4.85	9.99	12.0	119.88	24 7	27.8

Here as in the preceding table the cheese made on the same day are considered together, the conditions of the milk not being uniform from day to day, making it obviously unfair to compare one day's make with another. From the figures given it is apparent that in every case the quality of the cheese has improved with the increase of fat in the milk and that this improvement has more than compensated for the value of the extra fat in the richer cheese. It is not, however, proven by this that it paid to add cream to milk for the richer cheese. The milk used in these experiments contained originally about 4 per cent. of fat and should have yielded about ten pounds of cheese, 30 days old, from each 100 lbs. Such cheese would have sold for 10 cents per pound, which would have netted for the fat in the milk about the same price per pound as did that in the richer cheese. It does show that skimming the milk resulted in a loss as the fat abstracted was worth more in cheese than it would have been in butter. At this time butter was worth in Chicago about 29 cents per lb. It is probable that with the prices given, viz., 10.5 cents for cheese and 29 cents for butter it would have paid better to have skimmed off all of the cream and made butter of it than to have made the milk into cheese. It may be stated as a general rule that it never pays to skim off part of the cream and make both butter and cheese, and further that whenever the price of butter exceeds two and one-third times the price of cheese it will pay better to make butter than cheese, no account being taken of the difference in value of the skim milk and whey. If the relative value of skim milk and whey be taken into account butter should pay better than cheese whenever its price exceeds two and one quarter times the price of cheese—under other conditions cheese should pay better than butter.

3. THE YIELD OF CHEESE IN FACTORIES FROM DIFFERENT QUALITIES OF MILK AND AT DIFFERENT SEASONS OF THE YEAR.

All students who are candidates for dairy certificates from our school are required to send to us monthly reports of their work for one or two seasons. The reports from cheese fac-

tories give, along with other data, the average per cent. of fat in the milk and the average yield of cheese. During the past four years there have been received 347 reports from cheese factories in which both the per cent. of fat in milk and the yield of cheese are given.

In the following table are given averages of these reports arranged according to the per cents. of fat and also according to the season of the year:

Table showing yield of cheese in factories according to per cent. of fat in milk.

No. of groups.	No. of reports.	Range of fat per cent.	Average per cent. of fat.	Average yield of cheese per 100 lbs. milk.	Lbs. of cheese for 1 lb. fat.
1	24	under 3.25	3.126	9.194	2.941
2	90	3.25—3.50	3.382	9.235	2.730
3	134	3.50—3.75	3.600	9.407	2.613
4	43	3.75—4.00	3.839	9.806	2.562
5	46	4.00—4.25	4.090	10.300	2.512
6	20	over 4.25	4.417	10.707	2.407
All groups..	347	... .	3.64	9.566	2.628

Table showing yield of cheese in factories by months.

Month.	No. of reports.	Average per cent. of fat.	Average yield of cheese per 100 lbs milk.	Lbs. of cheese for 1 lb. of fat.
April	22	3.480	9.154	2.630
May	68	3.493	9.447	2.704
June	66	3.497	9.367	2.679
July	63	3.554	9.231	2.593
August	49	3.634	9.335	2.568
September	36	3.836	9.955	2.594
October	28	4.076	10.562	2.591
November	15	4.254	10.947	2.573
Whole season	347	3.64	9.566	2.628

Each one of the 347 reports from which these tables are compiled covers the work of a whole month in a cheese factory. As the average factory season is only about seven months there is represented altogether an equivalent of nearly fifty seasons in a single factory. The average amount of milk that these factories received was 3,929 lbs. per day; on this basis the amount of milk used would be 40,900,890 lbs., which would have produced over 3,800,000 lbs. of cheese. The extent of these observations taken, independently, by a large number of different persons, trained especially for this kind of work, must, on the average, give results which approximate the truth, under prevailing conditions, even when the carelessness of some of the factory operators is taken into account. The per cent. of fat given in each case is the average of the per cents. of fat in the different patrons' milk and is not necessarily the average per cent. of fat in the mixed milk, although it must approximate it very closely. The yields of cheese from 100 lbs. of milk are made up from the weights when the cheese were sold, at which time the age of the cheese ranged from ten to forty days and probably averaged about twenty days. Although the conditions under which the figures have been obtained varied in the manner stated, it is believed that they represent very nearly the average practical results in Wisconsin cheese factories, a great majority of the reports having come from this state.

If the figures can be depended upon they indicate that the yield of cheese is greater from rich milk than from poor milk, that if the season be left out of consideration the yield from rich milk is not as large in proportion to the fat as it is from poor milk, and finally that both the fat in the milk and the yield of cheese increases in nearly the same proportion as the season advances.

Because most cheese factories are closed during the winter it is customary in cheese districts to have, so far as practical, cows fresh in the spring. Such being the case, the increase in the per cent. of fat in the milk and the increase in the yield of cheese from month to month, shown in the second of the above tables, may be attributed to advancing lactation.

In order to compare milk containing different amounts of fat at the same season of the year there is arranged in the following table the yields of cheese for one pound of fat for each month, the same groupings being used as before. April and May and also October and November are given together on account of the small number of reports during these months:

Table showing yield of cheese for one pound of fat for each month.

Per cent. of fat.	April and May.	June.	July.	August.	September.	October and November.
	No.	No.	No.	No.	No.	No.
Under 3.25........	12–2.96	6–2.[illegible]9	3–2.89	3 2.88	....	....
3.25–3.50.... . .	33–2.73	23–2.74	20–2.70	11–2.7[illegible]	3–2.85	... .
3.50–3.75.	34–2.6[illegible]	32–2.63	29–2.5[illegible]	24–2.54	10–2.67	5–2.81
3.75–4.00..	7 2.53	3–2.47	7–2.46	7–2.53	13–2.61	6–2.62
4.00–4.25...	3–2.56	2–2.30	4–2.3[illegible]	3–2.35	9–2.47	15–2.64
Over 4.25..... . .	1–2.15	... .	.. ... .	1–1.95	1–2.1[illegible]	17 2.46

It will be seen that the results for each period, without exception, are entirely consistent with those obtained when the whole season is grouped together, the only irregularities being at points where few reports are available.

The conclusion arrived at from these data is that, at the same season of the year, rich milks do not yield as much cheese in proportion to the fat which they contain as do poor milks, but that a rich milk towards the end of the season may do as well as a much poorer milk earlier in the season.

Dr. Van Slyke* from a long series of carefully conducted experiments at New York cheese factories has concluded that the yield of cheese from 100 lbs. of normal factory milk is very nearly proportional to the per cent. of fat in the milk. All of his work has been confirmed by complete analysis of the milk which show that the casein was in his experiments practically proportional to the fat. His experiments show an average of 2.72 lbs. of green cheese for each pound of fat in the milk. The loss in curing for 20 days amounts to about

* 12th Annual Report N. Y. Agrl. Expt. Station, p. 473.

four per cent., which deducted from his average leaves 2.61 lbs. of cured cheese for one pound of fat against 2.628 lbs., the average for the season found from the students' reports, a difference so slight that it need not be considered. The same close agreement follows in the averages for each month of the season and only fails when results are arranged according to the fat in the milk. It appears to the writer that the discrepancy is only apparent and arises from the fact that in Dr. Van Slyke's experiments the poor milks used have nearly all been early in the season and the rich milks towards the end of the season, the gradation from one to the other having been gradual so that when the results are arranged according to the fat in the milk they are virtually arranged according to season as is done in the second table above with the students' reports. An attempt to arrange his results according to fat for each month shows that nearly all will fall within one or two groups which do not differ by more than one-fourth per cent., leaving so few results in other groups that they have little weight and consequently they cannot be studied in this way. With this explanation there is nothing inconsistent in the work done by Dr. Van Slyke and the results arrived at from the students' reports. In fact the two tend to confirm each other.

The conclusions reached in this article immediately bring into question the justice of paying for milk, in cheese factories, according to fat, it having been generally assumed as an argument in favor of this, that yields are proportional to the fat. In discussions over this point very little weight has been given to the better quality of cheese from rich milk, and it could very properly be left out, if the yield were proportional to the fat, as this circumstance would result in all cheese, from normal milk, being of nearly the same composition and presumably of the same quality, at least so far as the content of fat is concerned. Just as soon, however, as the yield of cheese in proportion to the fat in the cheese is diminished the per cent. of fat in the cheese is increased and this factor should be considered in determining the value of milk for cheese. In support of this point the experiments of Dr. Van

Slyke[1] show that the proportion of fat lost in cheese making is quite independent of the amount of fat in the milk. Usually the proportion lost is slightly less from rich milk than from poor milks. Experiments at the Minnesota Agricultural Experiment Station[2] and at the Ontario Agricultural College[3] lead to the same conclusions, and all work done at the Wisconsin Dairy School has confirmed them. Usually there are about .4 lbs. of fat lost from 100 lbs. of milk, the condition of the milk and method of manufacture making it sometimes a little more and sometimes a little less.

Applying this loss of fat to the milks in the first table gives, when the yield of cheese is considered, the following per cents. of fat in the cheese made from those milks.

Table showing the per cent. of fat in cheese from milks of different composition.

Per cent. of fat in milk.	Yield of cheese per 100 lbs milk.	Per cent. of fat in cheese.
3.13	9.19	29.7
3 38	9 24	32.3
3.60	9.41	34.0
3.84	9.81	35.1
4 09	10.20	35.8
4.45	10.71	37.8
Average. 3.75		34 1

The average per cent. of fat in these cheese is about what is usually found in cheddar cheese twenty days old.

A cheese from closely skimmed milk containing about 2 per cent. of fat is worth at the present time in New York about 2 cents per pound, and a full cream cheese with 34 per cent. of fat is worth about 10 cents per pound; the prices of partly skimmed cheese are intermediate between these as is seen

[1] 12th Annual Report N. Y Agrl. Expt. Station, p. 437.

[2] Bulletin 19, Minnesota Agrl. Expt. Station.

[3] Bulletin 95, Ontario Agrl. College.

by the following extract from the New York Market reports for December 1st, 1894:

Full cream cheese	9½-11 cents.
Light skims, prime	8 - 9
Part skims, common to good	5½- 7½
Part skims, fair to good	4½- 5½
Part skims, common	3½- 4
Full skims	2 - 3

The difference in the market value of such cheese as are quoted above is almost entirely due to the amount of fat which the cheese contains. There is a difference of about 32 per cent. of fat between a full cream and a full skimmed cheese, and the difference in price at the present time is about 8 cents per pound, or one cent for each four per cent. of fat. Applying this principle to cheese made from such milks as are considered in the last table leads to the results given below, the price of average full cream cheese being taken as 10 cents per pound. There is also given the amount realized from 1,000 lbs. of milk of each quality, on this basis as well as on the relative value plan and the pooling plan. In fixing the price for cheese no fractions less than one-fourth cent have been considered. The relative value plan is on the basis of 26.08 cents per pound for the fat in the milk, this being obtained by dividing the total value $58.65 by 224.9, the total fat in the milk.

Table showing price of cheese calculated from the per cent. of fat in the cheese, with money received from 1,000 lbs. of milk of different qualities, on this basis compared with that received on the relative value and the pooling plan.

Lbs. of milk.	Per cent. of fat.	Yield of cheese.	Value at 10 cents per lb.	Per cent. of fat in cheese.	Calculated value per lb.	Total value.	Amount received for 1,000 lbs. of milk.	
							Relative value plan.	Pooling plan.
1,000	3.13	91.9	9.19	29.7	.09	8 27	8.16	9.775
1,000	3.38	92.3	9.23	32.3	.095	8.77	8.81	9.775
1,000	3.60	91.1	9.41	34.0	.10	9 41	9.39	9.775
1,000	3.84	98.1	9.81	35.1	.1025	10.05	10.01	9.775
1,000	4.09	103.0	10.30	35.8	.105	10.81	10.67	9.775
1,000	4.45	107.1	10.71	37.8	.11	11.78	11.61	9.775
Total..	22.49	586.5	58.65			59.09	58.65	58 65

The close agreement between the value of the cheese calculated from the market reports in the manner described and that given by the relative value plan is strong evidence that the latter is approximately correct.

The value of milk calculated from the actual yield of cheese at 10 cents per pound is given not because it is a practical method of apportioning dividends, but because it has been assumed by some to represent the relative value of the several milks. This assumption is obviously incorrect as no cheese expert would class a cheese containing less than 30 per cent. of fat with the rich cheese in other groups and there should, in justice, be some concession from the poorer to the richer milks to compensate for the improved quality of the product. This the relative value plan supplies and at the same time encourages every milk producer to improve his cows and give them better care. It puts a stop to the common practice of watering and skimming of milk, which had so nearly wrecked the factory system under the pooling plan, and finally it establishes a uniform basis for the valuation of milk that is applicable to both creameries and cheese factories, the importance of which has been too generally overlooked. The justice of the method is no longer questioned in creameries in which it has been almost universally adopted, and it is believed by the writer that the plan will be equally acceptable in cheese factories, so soon as its relations to all sides of the question are better understood.

4. LOSS OF CHEESE IN CURING.

All cheese made at our dairy school are weighed when taken from the press and as often thereafter as opportunity offers, and finally they are weighed when sold. The data thus obtained shows the loss of weight for all ages up to six months under such conditions as prevail in our curing rooms. The cheese considered were all made by the cheddar process. They were mostly pressed in flat hoops and had an average weight of about 30 lbs. when green. All cheese up to 60 days old were kept in the curing room at the dairy building. The temperature of this room, as indicated by a Draper self-regis-

tering thermometer, has ranged from 55 degrees to 70 degrees F., and has averaged about 61 degrees F. Most of the time the temperature has been near the average. The moisture, shown by a Mittchoff hygrometer has averaged about 50 per cent. of saturation. Occasional observations with wet and dry bulb thermometers show that, within the range of moisture occurring in our curing rooms, the hygrometer is nearly correct. During the summer months the cheese still on hand have been removed to a room in the basement of the agricultural building where the temperature could be better controlled. A maximum and minimum thermometer placed in this room was read each week during the summer. The average maximum readings was 69 degrees F. and of the minimum readings 59.7 degrees F. The average temperature was probably about 65 degrees F. No determinations of moisture were made in this room, but the greater tendency of the cheese to mould showed the air to be more nearly saturated than in the other curing room.

In the following table showing the loss in weight the cheese are arranged in groups, those of nearly the same age being put together. The first three groups cover periods of ten days each. The fourth group includes all cheese between one and two months old, and the last group all over two months old. The average age of the cheese in each group is found by multiplying the number of cheese of the same age by the age, expressed in days, and dividing the sum of these products by the total number of cheese in the group.

Table showing average loss of cheese in curing.

No. of group.	Period covered.	Average age.	No. of cheese.	Total weight green.	Total weight cured.	Loss.	Loss.
	Days.	Days.		Lbs.	Lbs.	Lbs.	Per cent.
1	1-10	6	99	2,812	2,741.5	70.5	2.51
2	11-20	16	242	7,356.9	7,077.0	279.9	3.80
3	21-30	25	298	8,530.5	8,160.4	370.1	4.34
4	31-60	41	417	12,353.3	11,684.4	668.9	5.41
5	Over 60	141	172	6,244.4	5,736.0	508.4	8.11

Total number of cheese .... 1,235.
Average weight of green cheese .... 30.2 lbs.

The table shows that the loss in a given time is very much greater in the early stages than it is later, it being fully half as much during the first week as for the whole month and more than one-quarter as much as for five months.

5. CLEANING MILK, WITH A CENTRIFUGAL CREAM SEPARATOR, FOR CHEESE PRODUCTION.

Whenever a considerable quantity of milk is run through a centrifugal cream separator, there accumulates upon the inside of the bowl, a deposit of solid matter known as separator slime. It consists of coagulated albuminous matter with which is mingled all solid impurities heavier than milk. When removed from the separator bowl the slime rapidly undergoes putrifaction and gives off an offensive odor. No normal milk however carefully it may be handled is entirely free from it although the amount may be very small, except when milk is nearly sour, so that the casein has begun to precipitate. It seems plausible, however, on account of its offensive character and tendency to decay that the flavor and keeping qualities of any milk would be improved by its removal. It has even been proposed, for sanitary reasons, to treat all milk for domestic purposes in this manner. The late Professor Arnold was a strong advocate of this, although the writer is unable to refer to such a statement in his published works.

In the manufacture of cheese all solid matters contained in the milk are entangled in the curd and finally carried into the cheese, and it is reasonable that removal of slime from milk used for this purpose would be especially beneficial.

Experiments to test this question were begun in 1891 and have been continued each year since, during our dairy school. In all nearly 100 cheese have been made from milk cleaned in this way and without exception the flavor and keeping quality of the cheese has been improved.

It was early noticed, whenever there was a tendency to gassy or pin holey curds in the original milk, that this was either greatly improved or entirely removed by cleaning the milk. A large number of experiments made by students during the past two winters, when the milk used gave gassy

curds, confirmed our first impressions. In all of our work up to the close of the Dairy school in 1894 there was not a single exception to this rule, and we were firmly convinced that cleaning milk with a separator would remedy all difficulties of this nature and greatly improve the quality of cheese from tainted milks of any kind.

Thorough aeration of milk in the vat with a Hill's aerator, especially when the milk was first heated to about 100 degrees F. was also beneficial in suppressing pinholes in the curd, although this method was not as efficient as the use of a separator. This suggested the thought that the effect upon the pinholes in the first place was chiefly due to the thorough aeration which the milk received in the separator and not to the removal of the slime. In order to test this point two vats of milk were cleaned with a separator and afterward the slime obtained from all of the milk was added to the milk in one of the vats. The milk in both of these vats was made into cheese in the same manner. The curds from both vats were practically free from pinholes although other vats from the same milk that was not treated contained large numbers. This experiment was repeated on another day with practically the same results, and it seems likely that the supression of pinholes by passing milk through a separator was due to the aeration and not to removal of gas producing organisms in the slime. Further experiments accompanied by a biological study of the milk and slime are necessary to settle the point.

All of the experiments described above were conducted in the winter, and it was thought advisable before recommending the method as a sure remedy for pinholes to apply it to summer milk when such difficulties are usually much more troublesome. The establishment of a summer dairy at the Station gave facilities for this work. To our surprise cheese made by this process in July and August, when gassy curds were very common were not improved in this respect. So far as we could judge just as many pinholes were found in curds from the cleaned milk as from that not treated. The only explanation we can offer for these results at present is that possibly the

gas producing organisms most abundant in the milk used in the winter were of a different species from those in the milk used in the last experiments, and that the one species is rendered inert by exposure to air while the other is either not affected at all or is made more active by the treatment.

Biological examinations of this milk made by Dr. Russell show a variety of gas producing organisms in the summer milk, but as yet no comparison of the species found in the summer and winter have been made.

Although cleaning milk with a separator has not accomplished all that we had hoped in the treatment of milk for cheese, we feel that it has been of great benefit, as it has, in nearly every case, improved the quality of the cheese, and the improvement has been more marked with tainted milk than with those in good condition. Especially has it been of benefit for long keeping cheese as such have retained their flavor much better when made from separator cleaned milk.

For cleaning milk, as suggested, any separator which gives a smooth cream may be used, those machines where the cream flows over the edge of the bowl being best adapted for the purpose. We have generally used a standard De Laval separator in which the skim milk tube has been closed so that the skim milk and cream were forced over the top of the bowl together. It is better if the cream slot is also closed by carefully fitting a piece of leather into it. In this way a very homogeneous mixture of the skim milk and cream may be obtained. The milk to be cleaned should be warmed to between 100 --110 degrees F. as this, in a great measure, prevents churning and frothing of the cream. The milk as it runs from a separator should not flow directly into the milk, in a can, as this always results in more or less frothing. The best results are obtained by placing a fine hair strainer over the can through which the milk is run. If such a strainer is not available a clean board five or six inches wide placed in the can in a slanting position with its upper end just beneath the spout of the separator so that the milk will run down this and not fall in a heavy stream into the milk will accomplish the

same purpose. Very satisfactory results may also be obtained without closing the skim milk tubes by running the skim milk and cream together through a fine hair strainer.

The quantity of milk which may be cleaned with a separator is very much larger than the rated capacity of the machine for skimming; probably with proper appliances the capacity of a separator may be doubled. After all of the milk has been run into the separator it should be followed with sufficient water to replace most of the milk in the bowl, in order to prevent undue loss. The milk after it leaves the machine should be cooled as quickly as possible to near the point at which the rennet can be added. It is then handled in identically the same manner as other milks. As a rule we have found that such milks work a little more rapidly than untreated milks. This may be due to more rapid development of the lactic ferment at the high temperature to which the milk is heated.

The yield of cheese by this process is a trifle smaller than from untreated milk it being on the average about two-tenths pound less from 100 lbs. of milk. The loss of fat in whey is also a little higher. The difference is however more than balanced by the better quality of the product.

THE SOURCES OF BACTERIAL INFECTION AND THE RELATION OF THE SAME TO THE KEEPING QUALITY OF MILK.

H. L. RUSSELL.

It has been proven many times by experiments that milk from healthy animals when secreted in the milk gland in the udder is absolutely germ free. If milk would be secured and kept in this sterile condition it would remain unchanged for a long period of time, but during the milking and also subsequent to its withdrawal, it is subjected to so many contaminating influences, that it soon becomes fouled with living organisms which multiply so rapidly as to completely change the chemical and physical characters of the fluid in a very short time. Under ordinary conditions, the extent to which milk is infected by these different forms of bacteria varies much and is dependent upon the action of several factors. As the keeping quality of this fluid bears a definite relation to its germ content, any measures that tend to restrict the amount of germ life that gains access will also help to increase the keeping properties of the milk and so preserve its nutritive value. In this way not only will milk remain in a sweet condition for a longer period of time but the adoption of the suggestions detailed below will in a large measure exclude the possibility of the numerous undesirable fermentations that cause so much trouble in many dairies. Medical bacteriology has taught the important lesson that it is far easier to prevent an epidemic than it is to arrest its progress and heal the diseased. The same lesson must be learned by us in dairy bacteriology. The serious inroads that these micro

organisms make in the dairy industries can be largely prevented if we take pains to exclude them from the first.

The suggestions as outlined below do not include any new methods but are merely the outcome of what practical experience has found to be helpful in this matter. These methods, however, have been controlled by studies from a biological standpoint so that their real worth in excluding living organisms has been determined. A rational explanation of the effectiveness of these simple precautions would seem to be desirable.

When we consider the sources of the bacterial infection of milk and the relative importance of the different factors in accounting for the same, it will be evident that no general rule can be laid down that will be applicable in all cases, for the influence of the several factors will vary much in different instances.

INFECTION FROM UNCLEAN VESSELS.

One of the most important factors of the contamination of milk arises from the use of unclean vessels. Under this head, the actual presence of dirt and filth in dairy utensils is not necessarily intended, but the presence of germ life owing to the inefficient methods of cleaning that are often in vogue. Under ordinary circumstances the walls of vessels that have been in use are covered with numerous organisms and in the cracks and joints, myriads of germs are to be found. Cleansing with warm water will remove the bulk of the dirt and with this, the majority of the adherent bacteria, yet innumerable individuals escape all but a most thorough cleaning with scalding water or steam. Even the application of such stringent measures as these fail if they are applied for only a few moments. Bacterial life to be effectually destroyed must be subjected to the disinfecting action of boiling water or steam for several minutes. The forms that are in a growing condition are quickly killed at such a high heat but those in a spore stage are able to resist this temperature for a considerable length of time.

The following experiment shows what effect sterile milking vessels exert upon the amount of germ life in the milk.

Two covered milk pails were taken, one of which had been cleaned in the ordinary way, and the other sterilized by steam for half an hour. In order to exclude as far as possible the influence of other factors, the udder of the cow was thoroughly washed, the hands of the milker cleaned and the fore milk rejected. The milk was then received into the two pails and immediately cooled to 50° F., so as to stop the development of germ life. Gelatin cultures were prepared from these milks to determine the number of organisms present and there was found in milk taken in the sterile pail 165 germs per cc., while that which had been received in a vessel cleaned in the ordinary way contained 4265 bacteria for an equal volume. The milk was allowed to stand in the respective cans at the temperature of the room (68°-75° F.) until it soured. That taken in the unsterilized pail turned in twenty-three hours while that received in the sterile pail remained sweet five and one half hours longer.

Numerous repetitions of the same method of procedure often showed still greater differences; in some cases there being a difference of 15 hours in the length of time before the milk began to turn. These experiments were confined entirely to the milking vessels but the same influences are at work in connection with all other kinds of dairy utensils. Cans in which the milk is set for creaming, all dippers and strainers should be rendered as germfree as possible so that the number of organisms added to the milk will be reduced to a minimum. Under average conditions, it may be confidently asserted, that with this simple precaution alone, the marketable period, i. e., the length of time during which milk remains sweet may be extended from six to ten hours.

INFECTION FROM FORE MILK.

Another important source from which the milk derives its germ life is by the mixing of the first milkings or fore milk with the whole mass. While the milk as secreted in the milk glands is sterile that which is first milked out is always contaminated with bacteria. This is due to the infection from without and happens in this way. Even when the milking is most carefully done, a few drops remain in the teat that are not entirely squeezed out. As myriads of bacteria are spread over the surface of the udder and as there is a direct communication by means of the open end of the teat with the particles of milk that remain in the duct, it always happens that these few droplets become infected from the outside. Here, under these conditions, is to be found the very best environment for rapid growth. Moisture is abundant, the milk offers a rich nutritious medium while the temperature is considerably higher than the outside. The access of a very few germs from the outer surface will suffice to people this duct with innumerable bacteria, so that when the animal is milked at the next milking, these organisms are washed out into the whole mass, thus contaminating the entire product.

Usually this fore milk does not contain a large number of varieties although the number of individuals may be great. In examining a sample of milk biologically, the distribution of species is very unequal. The majority of individual organisms will be included under one or two forms while there will be a much larger group of species represented, that will contain only a limited number of individuals.

To ascertain the proportion existing between the number of organisms in this fore milk and those in the whole milking, the experiment detailed below is given.

Without any other precaution except a careful washing of the teats, the fore milk from each milk duct of a single cow was milked into a sterile flask; the remainder of the

milk was secured in the ordinary way. An analysis of these two milks by culture methods showed that the fore milk contained 2800 organisms per cc. while the average of the remainder of the milk only had 330 germs for the same volume.

The character of the bacteria in each sample presented marked differences; those in the fore milk belonged to a single species of the lactic acid group of organisms while those in the mixed milk were included under several different forms, the majority of which belonged to the rennet-forming species that produce such profound changes in the character of the milk.

INFECTION DERIVED FROM ANIMAL AND MILKER.

A third source of infection is the animal and person of the milker. The hairy coat of the cow is invariably filled with dust particles to which innumerable bacteria are attached, and the continual shaking movements of the udder during the milking process dislodge bits of filth, dust and hair which fall into the pail during the milking. Where animals are stabled for a large portion of the day and are not carefully cleaned, their under parts become very much fouled with particles of excreta. Particularly is this so with reference to modern conditions as the increased feeding of recent years produces a more fluid manure that is richer in nitrogenous elements and therefore more liable to undergo decompositions of a bacterial nature. Then, too, the animal often acquires a rich coating of organisms, especially on its under parts, if it has access to pastures where slime-covered mud holes are to be found.

The amount of actual impurities of a solid nature that gain access to the milk in this way are by no means inconsiderable, as is evidenced by the deposition of these in a few hours upon the bottom of a vessel full of milk. It makes but little difference if these are removed by straining, for the germs that are introduced with them are washed off in the warm nutrient fluid and will pass any kind of a strainer.

Very much can be done to eliminate the influence of this factor by keeping the udder and flanks well carded and brushed, as most of the loose hairs and dirt are removed in this way; but this does not strike at the root of the trouble. As long as the surface is dry, dust particles are easily dislodged, and these tiny bits of matter fall in a continual shower into the milking pail. If these under surfaces are well moistened, the opportunity for the displacement of germ life will be very much diminished. Bacteria cannot be dislodged from a moist surface except by very violent movements. The air over large oceanic bodies of water is absolutely germ free, although the waters below are often teeming with scores of these tiny organisms in every drop. The explanation of the beneficial effect of the custom of washing the udder is then, that the bacteria are kept in place, for if the surface of the animal is thoroughly moistened, the germs are in large measure prevented from falling into the milk.

It is highly important that this source of infection be diminished to the greatest possible extent, for the bacteria that gain access in this way belong, in most part, to those forms that produce undesirable changes in milk. Then, too, the bacteria associated with filth and dirt of this kind are usually species possessing spores and therefore capable of great resisting powers. On this account they are difficult to eradicate, even where heat is used.

If this precautionary measure is carried out with reference to the animal, it is also necessary to use care and caution concerning the person of the milker. The hands of the milker should be cleaned with soap and warm water *immediately preceding* the milking. It is also well to have the milker, especially the upper portion of his body, clothed in an outer garment kept for this purpose. Numerous experiments have been made during the past year to determine the effect of this factor. The method of experimenting was as follows: While the milking was in progress a glass dish several inches in diameter that had a thin layer of sterile nutrient gelatin on the bottom was ex-

posed underneath the cow at the height of the milking pail and in close proximity to the same. After the plate had been exposed for a definite number of seconds, the cover was quickly replaced so as to prevent further contamination. In this way the germs that are derived either from the air or from the surface of the animal settle on the moist layer of the sterile gelatin and begin to develop. In the course of 36 to 48 hours, tiny spots of varying size appear. These are the so-called "colonies" that are formed from the growth of a single organism that is deposited on the exposed gelatin surface. By counting these and determining the relation between the exposed area of the culture plate and the milk pail, an approximate idea may be obtained of the number of germs that fall into the milk from the surface of the animal. If this method is tried during the first part of the milking and then repeated after the udder and under parts of the animal are cleaned and thoroughly moistened with water, the two exposures serve as checks upon each other; the first one giving an approximate idea of the amount of infection derived under ordinary circumstances, the second showing the effect of these simple precautions upon the germ life that gains access to the milk.

This method cannot be rigidly accurate, for the rate of deposition of dust and dirt is by no means constant, but it is fair to assume that the method indicates in a general way the effect that this precaution has upon these conditions.

The following data show the value of this treatment. The figures given below are all reduced to the same scale, viz., the number of organisms, as revealed by the plate cultures, that were deposited *per minute* in a milk pail having a diameter of ten inches. If these figures are multiplied by the number of minutes consumed by the milking, a rough estimate may be made of the number of individual organisms that are added directly to the milk in this way at a time when it has a high temperature greatly favoring rapid reproduction.

EFFECT OF WASHING UDDER ON THE BACTERIA IN MILK.

TABLE 1.

Date.	Treatment of cows.	Estimated No. of bacteria deposited per minute on 78 sq. in. of surface (10-inch milk pail).		Reduction of organisms in percentages.
		Ordinary conditions.	Udder and flank washed.	
Nov. 6	Stabled	16,400	2,600	85 per cent.
Nov. 10	Stabled	4,010	1,860	54 per cent.
	Stabled	1,700	560	66 per cent.
Nov. 24	Stabled	4,165	1,370	69 per cent.
Feb. 20	Stabled	1,800	1,300	27 per cent.
March 3	Stabled	2,700	330	88 per cent.
Aug. 23	Pastured	3,960	114	96 per cent.

Figures 1 A and 1 B illustrate the experiment made on March 3rd, where the reduction was 88 per cent. of entire number. Each of the tiny points indicates a colony that has developed from an invisible germ that fel. on the sterile surface. The difference in size of these spots is one of the characters that enables the observer to separate one species from another.

Fig. 1 A, which shows over one hundred and sixty colonies on a circular area 3½ inches in diameter, illustrates the actual amount of germ life that was caught on the sterilized moist surface in a period of thirty seconds under the ordinary conditions in which the milk was secured; in connection to this, there was present on a control plate, Fig. 1 B, of an equal area, that was exposed for an equal length of time at the same spot only twenty colonies, where the udder was cleaned and washed before the milking occurred.

FIG. 1.— Effect of washing the udder on the bacteria present in milk. Figure reduced one-third.

A.—Culture plate of gelatin exposed under udder of cow for thirty seconds while milking under ordinary conditions.

B.—Duplicate culture exposed for same time at same spot where udder and flank of animal had been washed before milking.

Each white spot represents a colony of bacteria that has developed from a germ that has fallen on the plate.

Where the exposure is made in the above way, it is a difficult matter to determine the amount of infection that comes from germs floating in the air from that which is derived from the animal itself. The barn air is at all times richer in germ life than that outside, so that in the above figures it is not unreasonable to suppose that a part of those germs deposited upon the plate after the udder of the animal had been treated in this way really came from the germ laden air. That this is true is seen from the experiment made August 23rd, where the cow was milked out of doors. During the exposure of the sterile plate under the animal after it had been washed, another plate was simultaneously exposed to the air some distance away from the cow. While 114 germs were deposited under the cow, 65 were found on the plate exposed simply to the air. The extent of diminution is therefore really greater than would appear from the foregoing table.

INFECTION FROM THE BARN AIR.

The effect of this factor can not well be separated from that arising from the animal, yet certain methods of feeding and the occurrence of these with reference to the milking have a decided influence upon the bacterial contents of the air of the stable and subsequently upon the germ life found in the milk.

Where hay, straw or coarse dry fodder is used, the barn air is much infected with dust particles to which the bacteria are attached in large numbers. A gelatin plate exposure made in the stalls during the feeding showed that over 160,000 organisms were deposited per minute on an area covered by an ordinary milk pail.

Figure 2 shows how thickly the bacteria cover any exposed surface under these conditions. The following illustration represents the actual deposition of organisms as it occurred on a plate 3½ inches in diameter for thirty seconds during the time in which dry feed, like hay, was being fed to the cattle. The smaller more sharply defined spots are colonies of bacteria, the larger diffused areas being moulds

that likewise are present in large numbers in dust laden air.

If the feeding with these dry fodders is done at the same time that the milking is carried on—a common occurrence in many dairies—the danger from contamination is considerable. An exposure of sterile gelatin plates during this feeding will show a high increase in the number of bacteria in the air. These settle with the dust, and in doing so inevitably gain access to the open milk vessels. In this way, the hay bacillus and allied forms that are of a resistant character find their way easily into the milk.

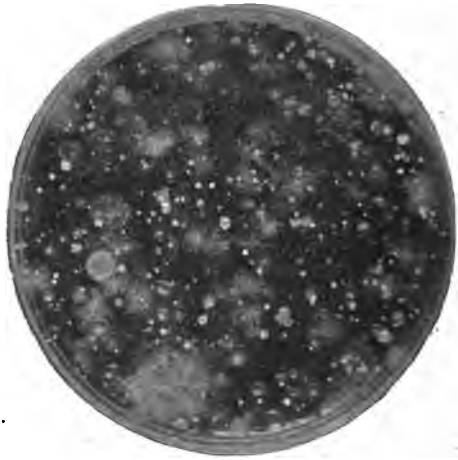


FIG. 2.—Showing deposition on three and one-half inch gelatin plate of organisms from barn air during the feeding of dry feed (hay). Figure reduced one-third.

This source of danger can be eliminated by feeding moistened feed during the milking, or the dry feed immediately subsequent to this operation, but after the milk has been removed from the stable. A biological analysis of mixed milk that is taken in the ordinary way will invariably show the presence of numerous individuals like those that are to be found in the air and on the surface of the coarse dry fodder.

THE UNITED EFFECT OF ABOVE PRECAUTIONS.

If the milking is carried out in the light of the above suggestions, a very radical difference in its germ content will be observed. These precautions require for their ful-

fillment only a little extra labor, but this labor is more than compensated for in the purer condition of the milk. By these precautionary measures the germ content of the fluid may be greatly reduced. In fact, the keeping quality of the milk may be increased to such an extent that it will remain sweet from 24 to 48 hours longer than it otherwise would.

The influence of unclean vessels can be entirely eliminated by steaming or thoroughly scalding the different utensils; the bacteria present in the fore milk can be greatly reduced by rejecting the first few streams from each teat; the germ life associated with manure and filth particles that fall into the milk from the dirty udder and under parts of the cow can be much lessened by cleaning these parts and thoroughly moistening them with water so that dusty particles will not be dislodged from the hairy surface; and the influence of the infected barn air can be much lessened by the removal of the milk as soon as milked and taking care that operations like dry feeding or bedding are done after the milk is removed from the stable.

The following example shows to what extent the bacteria of the milk can be controlled by rational methods of milking: In October the mixed milk taken in the ordinary way was found to contain 15,500 germs per cc., while the average of the total yield of a cow that had been carefully cleaned and the milking done in the manner already suggested contained only 330 bacteria for the same volume. In February, under winter conditions, a repetition of the same experiment revealed a still smaller number, there being 7,680 germs per cc. in the mixed milk, while that received in open sterile pails, but with greater care, had only 120 bacteria for the same volume. Figs. 3 A and 3 B illustrate the extent to which the bacterial contents of the milk taken during the above experiment were reduced. In each of the gelatin cultures an equal amount of milk (one-thirtieth cub. cent.) was added so that the relation between the number of colonies shows the proportional reduction.

FIG. 3.—Showing the influence of precautionary measures in milking on the germ contents of thmilk.

A.—Gelatin plate showing organisms in 1-30 cc of milk where milk was secured under ordinary conditions.

B.—Duplicate culture containing 1-30 cc. of milk where the milk was secured with all possible care.

Such a diminution as this, amounting as it does in this case to over 98½ per cent. of the total number of bacteria that were present in ordinary mixed milk must have a marked effect upon the keeping properties of the same. In the case under consideration, at room temperature, there was a difference of 24 hours in time before both soured, in favor of the milk secured with this extra care.

RELATION OF TEMPERATURE TO BACTERIAL GROWTH.

These suggestions suffice to point out the sources from which the milk derives its quota of bacterial organisms, but the effect of such a treatment as indicated above will be practically nullified unless one other condition is taken into consideration—that of the temperature at which the milk is kept. The rate of bacterial growth is so dependent upon this factor that this relation must always be considered in studying the effect of these living organisms on the changes that occur in milk. If the temperature of the milk is maintained at a high degree, or if the milk taken under these precautions is allowed to cool spontaneously, the radiation of heat will be so slow that although the milk may be seeded with only a small fraction of the ordinary germ content, yet the rate of reproduction will be so augmented that the total amount of germ life will not be materially diminished, and consequently the keeping property of the milk will not be increased. It is for this reason very essential that the milk should be cooled *immediately* after it is drawn from the cow. Immediate lowering of the temperature of the milk not only retards the growth of those bacteria that gain access to this fluid in a growing vegetating condition, but it diminishes the rapidity of germination of those organisms that may have found their way into the milk in a latent, spore state. Particularly is this true with the forms that are derived from the air and dried bits of dirt and dust, for these organisms, being in a quiescent condition, are unable to begin active multiplication at once.

Bacteria, like all other vegetable organisms, require a certain temperature before germination will occur. This point, as a rule, is higher than that at which growth is possible, so that if the germination of the latent spores can be held in abeyance until the temperature is reduced below this point growth cannot occur.

The minimum temperature limit below which the different species of bacteria germinate do not always coincide, but in general it is not far from 50°–60° F. If the temperature is high enough to allow the germination of the spores, growth and multiplication will take place readily, and if germination once occurs, the young cells will reproduce slowly at a much lower temperature.

CONCLUSION.

An observance of the above conditions will do much to lessen the rate of germ development and so increase the period during which milk retains its normal characteristics. Especially will this be true where any endeavor is made to carry out the suggestions outlined in the preceding pages to diminish the amount of germ life that is added to the milk from the very beginning. Just so far as we can keep out bacterial organisms from the milk, just so far can we succeed in increasing its keeping qualities and in eliminating all of those undesirable taints and offensive fermentations that are not only a source of annoyance but often a serious hindrance to the manufacture of high grade products.

The question, although largely a biological one, rests primarily upon two simple physical conditions, namely,

CLEANLINESS AND TEMPERATURE.

Not only must thorough cleanliness in every detail be insisted upon in securing and handling the milk after it is drawn from the cow, but the animal herself must be cared for in such a way, and her surroundings must be of such a

nature, as to diminish to the greatest extent the possibility of contamination to the milk during its withdrawal.

Co-ordinate in importance with this condition is the storage of the milk at the lowest possible temperature if its keeping qualities are to be increased by a diminution in the germ contents of the fluid.

ON THE EFFICIENCY OF TUBERCULIN AS A DIAGNOSTIC AGENT IN TUBERCULOSIS.

H. L. RUSSELL.

Since the introduction of Koch's tuberculin in 1891 as an agent in diagnosing bovine tuberculosis, its use has been much increased. It has been extensively tried in Europe and within the last two years has been introduced into this country. Under the auspices of the various experimental stations and state veterinary departments, a large number of experiments have been made with it. Its value is now fully recognized, and expert veterinarians find its use indispensable in the more accurate diagnosis of this disease that presents so many occult phases in its appearance in cattle.

Although the consensus of opinion based upon actual experiments is overwhelmingly in favor of its use as a diagnostic agent, yet our knowledge concerning it is far from being complete and it is essential that carefully collected records concerning its use should yet be made.

While tuberculin has been shown in a great number of instances to be absolutely infallible in its diagnostic property, yet it is an agent that can be very easily misused and herein lies the chief objection to it.

Its ability to detect incipient, as well as aggravated cases of the malady depends entirely upon the temperature readings. In this the personal equation of the experimenter must be large, and in doubtful cases very much depends upon his judgment. Unless the data upon which his judgment is to be based is very full and explicit, he may very easily fail to make a correct diagnosis, and in doing so, is unable to extirpate the disease from the herd.

It is therefore absolutely essential that the temperature records should be very full, both the normals before injection, and the inoculation temperatures subsequent to the introduction of the tuberculin. For this reason, the detailed temperature readings of quite a number of those animals that have been tested with tuberculin are given below. In all but four cases, the inoculations were made either by Dr. W. G. Clark, Instructor in Veterinary Science in the Short Course, or the writer.

Bulletin No. 40 gave the results of the experiments with tuberculin upon the Station herd but the temperature records are again recorded in this place in connection with those that have been made at a later date.

I.

RESULTS WITH STATION HERD AT UNIVERSITY FARM.

First inoculations.—It was originally intended to make a comparative test of the tuberculin manufactured by Dr. Libbertz of Berlin, Germany, and that which is made in the Biochemic Laboratory of the Bureau of Animal Industry, Washington, D. C., but this experiment was frustrated by our inability to secure at the proper time enough of the imported liquid to use the regulation dose that is recommended. The inoculations, however, were made with very dilute doses in order that the effect of these ultra-minimal amounts upon the constitution of the animal might be studied.

TABLE 1 A.—*Ante-injection temperature records of Herd I.—(First inoculation).*

No.	NAME.	Breed.	Age.	4 P. M.	6 A. M.	8 A. M.	12 M.	4 P. M.	8 P. M.	Average normal temperature.	Date of inoculat'n.	Am't and kind of tuberculin.	Weight of animal.
	Lot I.												
1	Polly	Gr. J.	18 mos...	....	....	101.3	101.8	101.6	101.	101.42	10 P. M., Feb. 20.	2 cc., B*..	776
4	Gay	Jer....	6 yrs.....	....	....	101.	100.9	101.3	101.	101.05	10 P. M., Feb. 20.	2 cc., B...	871
9	Daisy............	Gr. J.	14 yrs. ...	....	....	99.6	101.2	101.4	101.2	100.85	10 P. M., Feb. 20	2 cc., B...	778
2	Bessein..........	Gr. J.	5 yrs.....	101.8	... .	101.6	101.4	102.	.. ... .	101.70	5 P. M., Feb. 23.	2 cc, B...	992
3	Doubtful	Gr. J..	5 yrs.....	101.5	....	101.6	101.4	101.2	. ...	101.42	5 P. M., Feb. 23.	2 cc., B...	952
5	Aaggie	Hol...	5 yrs....	101.1	....	101.7	101.	101.3	. ...	101.28	5 P. M., Feb. 23.	2 cc., B...	1,017
6	Galena	Gr. J.	5 yrs.....	101.2	... .	102.2	100.4	101.	....	101.20	5 P. M., Feb. 23.	2 cc., B...	978
15	Melvina	S. H.	5 yrs.....	101.8	....	102.1	102.	102.	....	101.97	5 P. M., Feb. 23.	3 cc, B...	1,280
16	Miss Cowslip...	S. H.	4 yrs....	101.	....	101.8	100.8	101.6	....	101.30	5 P. M., Feb. 23.	2.75 cc., B	1,327
	Lot II.												
7	Rue	Jer....	10 yrs....	103.3	101.4	... .	99.4	100.	... .	101.25	4 P. M., Mar 13.	.03 cc., K	980
8	Neth. Nugget ...	Hol...	3 yrs......	100.2	100.6	....	100.4	101.7	....	100.73	4 P. M., Mar. 13.	.0375 cc., K	1,122
10	Bunn	Gr. H.	11 yrs.. ..	102.3	102.2	....	101.8	102.	....	102.08	4 P. M., Mar. 13.	.0375 cc., K	1,260
11	Beauty..........	Nat...	12 yrs....	101.1	101.2	.. ..	99.6	101.6	....	100.88	4 P. M., Mar. 13.	.03 cc., K	1,120
12	Bessie, 2d	Gr. J.	7 yrs	102.	102.	. ...	100.4	101.8	....	101.55	4 P. M., Mar. 13	.025 cc, K	930
13	Palmyra.........	Gr. J.	5 yrs......	101.2	101.7	....	100.6	101.6	. ...	101.28	4 P. M., Mar. 13.	.025 cc., K	906
14	Pansy	Gr. J.	2 yrs......	102.3	102.	....	101.6	101.9	....	101.95	4 P. M., Mar. 13.	.025 cc., K	816
17	Clothilde Rosa...	Hol...	5 yrs......	103.	104.	....	101.7	104.9	. ...	103.40	4 P. M., Mar. 13.	.03 cc., K	1,077
18	Colantha Rosa...	Hol ..	18 mos ...	102.1	102.1	....	102.	102.1	....	102.08	4 P. M., Mar. 13.	.03 cc., K	933
19	Experimentalist..	Jer....	3 yrs.. .	101.1	101.5	....	101.	102	....	101.40	4 P. M., Mar. 13.	.0375 cc., K	1,336

TABLE 1 A.—Continued.

No.	NAME.	Breed.	Age.	4 P. M.	6 A. M.	8 A. M.	12 M.	4 P. M.	8 P. M.	Average normal temperature.	Date of inoculation.	Am't and kind of tuberculin.	Weight of animal.
	Lot III.												
20	Lady Mosscoat...	S. H.	2 yrs.....	....	....	102.	102.1	101.8	....	101.95	5 P. M., May 2....	.03 cc., K	1,023
21	Melrose.........	S. H..	18 mos....	....	....	101.8	101.4	101.9	....	101.75	5 P. M., May 2....	.0225 cc., K	830
22	Pet.............	Ayr...	16 mos..	....	....	102.1	102.5	101.9	....	102.12	5 P. M., May 2....	.0225 cc., K	684
23	Galatea.........	Gr. J.	5 mos....	....	....	....	102.8	102.7	....	102.75	5 P. M., May 2....	.0125 cc., K	400
24	Melnotta........	S. H	4 mos....	....	....	....	102.8	102.8	....	102.80	5 P. M., May 2...	.0125 cc., K	295
25	Rosette.........	Gr. J.	5 mos.....	....	....	....	102.4	102.3	....	102.35	5 P. M., May 2 ..	.0125 cc., K	275
26	Nugget..........	Hol...	6 mos....	....	....	....	102.8	102.9	....	102.85	5 P. M., May 2 ..	0125 cc., K	456
27	Blossom.........	Gr. J.	5 mos....	....	....	102.9	101.6	102.5	....	102.45	5 P. M., May 2...	015 cc., K	366
28	Augustus........	Hol...	6 mos. ...	....	....	102.5	101.8	102.5	....	102.32	5 P. M., May 2....	.019 cc., K	678
29	Chloe...........	Hol...	4 mos....	....	....	....	102.7	102.3	....	102.45	5 P. M., May 2...	.0125 cc., K	340
30	Josephine.......	Gr. J.	7 weeks...	....	....	102.4	101.9	102.5	....	102.35	5 P. M., May 2....	.011 cc., K	184

*B=Bureau Animal Industry tuberculin. K=Imported tuberculin (Koch's).

TABLE 1 B.—*Post injection temperature records of Herd I. (First inoculation.)*

No.	Name.	Average normal temperature.	6 hours	8 hours	9 hours	10 hours	11 hours.	12 hours.	14 hours.	16 hours	18 hours	20 hours.	21 hours.	28 hours.	40 hours	Reaction above average normal.	Reaction above highest normal.
	Lot. I.																
1	Polly..........	101.42	....	....	103.9	......	101.9	106.	**106.2*	105.4	105.	105.4	......	....	....	*4.8*	*4.6*
4	Gay......	101.05	....	....	101.7	....	102.7	103.9	*104.4*	104.	102.5	101.5	......	....	....	*3.4*	*3.1*
9	Daisy	100.85	....	...	102.4	....	*103.8*	95.5	100.6	102.4	102.4	101.5	.....	....	....	*3.0*	*2.4*
2	Bessein........	101.70	....	102.8	....	102.7	......	103.3	103.2	103.8	102.6	102.4	....	....	....	1.6	1.3
3	Doubtful	101.42	.....	101.2	....	101.5	......	101.9	102.3	103.1	102.4	101.6	....	....	....	1.7	1.5
5	Aaggie	101.28	....	102.8	....	104.	.....	105.2	*105.6*	104.6	103.8	102.3	....	......	....	*4.3*	*3.9*
6	Galena..........	101.20	....	101.8	.....	102.4	....	103.4	101.2	*104.9*	103.7	103.7	....	....	....	*3.7*	*2.7*
15	Melvina.........	101.97	....	105.2	.....	*106.4*	......	106.3	105.6	100.4	105.	105.1	.....	....	....	*4.4*	*4.3*
16	Miss Cowslip...	101.30	....	101.6	....	102.	....	102.2	102.5	101.5	101.8	101.9	....	....	....	1.2	0.9
	Lot. II.																
7	Rue............	101.25	101.2	102.2	....	101.5	....	102.8	101.2	....	101.6	98.7	102.	....	....	1.6	1.4
8	Neth. Nugget..	100.73	101.7	102.	....	101.9	....	102.1	102.4	.....	*103.5*	101.8	102.4	....	......	*2.8*	*1.8*
10	Bunn	102.08	101.6	101.4	....	101.4	....	101.6	101.5	....	102.7	102.1	102.7	....	....	0.6	0.4
11	Beauty.........	100.88	100.6	101.2	......	101.2	....	101.3	101.6	....	102.5	101.	101.9	....	......	1.6	0.9
12	Bessie 2d	101.55	101.6	101.7	....	101.4	....	102.1	102.1	....	*104.6*	103.2	102.5	....	....	*3.1*	*2.4*
13	Palmyra.	101.28	102.	101.6	....	101.7	....	102.3	103.2	....	*104.9*	102.4	102.2	....	....	*3.6*	*3.2*
14	Pansy	101.95	102.	102.	....	102.	....	102.3	102.5	....	*104*	102.1	102.8	......	....	*2.0*	*1.7*
17	Clothilde Rosa .	103.40	105.5	105.3	....	104.7	....	105.2	105.5	....	105.2	104.5	101.8	106.	*106.3*	*2.9*	*1.4*
18	Colanthe Rosa .	101.86	102.5	102.4	....	102.8	....	103.3	104	....	*106.5*	105.	103.3	103.2	103.7	*4.6*	*4.4*
19	Exp'rimentalist	101.40	101.4	101.	....	101.9	....	102.4	102.3	....	105.7	*106.5*	105.2	101.2	104.8	*5.1*	*4.5*

TABLE 1 B.—Continued.

No.	Name.	Average normal temperature.	6 hours.	8 hours.	9 hours.	10 hours.	11 hours.	12 hours.	14 hours.	16 hours.	18 hours.	20 hours.	24 hours.	28 hours.	40 hours.	Reaction above average normal	Reaction above highest normal.
	Lot. III.																
20	Lady Mosscoat.	101.95	....	....	....	....	....	**104.7**	....	104.	104.7	....	....	....	....	**2.8**	**2.6**
21	Melrose	101.75	....	....	....	....	....	102.8	....	**106.5**	105.9	....	....	....	....	**4.7**	**4.6**
22	Pet	102.12	....	....	....	....	....	100.8	....	102.1	102.	....	....	....	....	0.0	—0.4
23	Galatea	102.75	101.8	102.5	....	103.2	....	103.4	....	**105.4**	104.7	105.4	....	....	....	**2.6**	**2.6**
24	Melnotta	102.80	103.2	101.4	....	105.8	....	105.9	....	**106.6**	106.	105.8	....	....	....	**3.8**	**3.8**
25	Rosette	102.85	102.8	103.6	....	104.4	....	104.7	....	**105.5**	104.4	105.2	....	....	....	**3.1**	**3.1**
26	Nugget	102.85	102.5	103.5	....	104.5	....	**106.5**	....	106.4	106.3	106.5	....	....	....	**3.8**	**3.8**
27	Blossom	102.45	....	....	....	....	....	105.8	....	106.2	**106.8**	....	105.8	....	....	**4.4**	**3.9**
28	Augustus	102.32	....	....	....	....	....	103.7	....	103.9	**104.8**	....	103.1	....	....	**2.5**	**2.3**
29	Chloe	102.45	102.8	102.8	....	102.9	....	104.7	....	**105.6**	105.5	104.6	....	....	....	**3.1**	**2.9**
30	Josephine	102.35	...	......	......	....	....	101.8	....	102.1	102.3	....	....	....	....	0.0	—0.1

* Bold face type indicates maximum injection temperature reached in diseased animals.

Tables 1 A and 1 B represent the temperature readings of the entire Station herd (1 A before the inoculation, 1 B subsequent to injection) as they were taken at the time of the first inoculation of each animal. The records of those animals on pages 168 and 170 belong to the series in which the two brands of tuberculin were used, Lot I being inoculated with the Bureau product, while Lot II received the imported material. Temperature records of animals on pages 169 and 171 are those of the young stock and calves (Lot III) that received only a single injection.

The foregoing summary includes the entire list of animals of the herd, all of which were inoculated with tuberculin at one date or another. Of the thirty animals so treated, twenty-two in all responded to the tuberculin test. Nine were inoculated with Bureau tuberculin (Lot I), of which six showed reaction temperatures. Of the twenty-one inoculated with imported tuberculin, ten were mature (Lot II) and eleven were young stock (Lot III). Of the ten, seven were diagnosed as diseased; and of the young animals, nine out of the eleven showed a diseased condition by the test.

Second Inoculations.—A second test was made later with the full grown animals, using in all cases a different kind of tuberculin from that which was employed at first. After the lapse of at least a month (seven weeks with most of the herd), this second series of tests were made, the results of which are incorporated in Table 2.

During this necessary lapse of time, the animals were unfortunately housed in the same barn and subjected to the same conditions under which they had been living, so that there was a possibility of an infection subsequent to the first inoculation.

Table 2 includes the data gathered at the second inoculation, showing both preliminary normal temperatures and the temperatures after injection.

ABLE 2.—*Temperature records of Herd I. (Second inoculation.)*

No.	Name.	Before Inoculation. 4 P. M.	6 A. M.	12 M.	3 P. M.	Aver. normal temp.	Amt. in cc. and kind used.	After Inoculation. 9 P. M. 5 hrs.	12 P. M. 8 hrs.	2 A. M. 10 hrs.	5 A. M. 13 hrs.	8 A. M. 16 hrs.	10 A. M. 18 hrs.	12 M. 20 hrs.	4 P. M. 24 hrs.	Reac. above aver. n'rmal.	Reac. above highest n'rmal.
	Lot. I.																
1	Polly	102.3	102.3	100.6	101.8	101.70	.0275 K	103.7	104.5	104.9	***105.1***	103.4	102.7	101.6	...	***3.4***	***2.8***
4	Gay	101.2	101.6	99.7	101.4	101.00	.0275 K	101.3	101.2	101.1	101.5	101.7	101.5	101.1	...	0.7	0.1
9	Daisy	101.1	102.2	99.9	101.7	101.22	.03 K	101.9	101.2	101.7	101.7	101.8	102.	102.3	99.7	1.1	0.1
2	Bessein	101.1	101.8	101.8	101.1	101.45	.02 K	101.5	101.5	101.2	101.4	102.	102.9	101.5	...	1.4	1.1
3	Doubtful	101.7	101.4	102.	101.5	101.65	.02 K	101.4	101.2	101.8	102.5	102.2	102.1	102.	...	0.8	0.5
5	Aaggie	101.4	101.6	102.7	100.1	101.45	.021 K	102.2	102.	101.8	102.	102.2	102.4	102.9	102.7	1.5	0.2
6	Galena	101.2	101.8	101.8	99.7	101.38	.021 K	101.7	101.7	101.6	101.7	102.2	101.8	101.6	...	0.8	0.0
15	Melvina	101.1	101.1	101.1	101.2	101.12	.025 K	102.3	101.8	101.9	102.4	101.9	102.2	***103.1***	103.	***2.0***	***1.9***
16	Miss Cowslip	102.	101.9	103.2	101.4	102.12	.025 K	102.5	101.8	102.4	102.1	103.5	103.4	103.4	...	1.4	0.2
	Lot. II.																
7	Rue	100.5	101.5	101.4	100.3	100.92	2.0 B	101	101.	101.4	103.1	104.	***104.5***	101.4	...	***3.5***	***3.0***
8	Neth. Nugget	101.3	101.3	101.8	101.8	101.68	2.5 B	101.5	101.8	102.2	103.3	***105.2***	101.9	104.7	...	***3.5***	***3.4***
10	Bunn	101.3	101.3	101.3	101.3	101.30	2.0 B	100.9	101.3	101.5	***103.4***	103.3	102.6	102.4	...	***2.1***	***2.1***
11	Beauty	101.6	101.5	101.8	101.5	101.60	2.1 B	101.6	101.4	201.8	102.6	102.9	102.7	102.5	...	1.3	1.1
13	Palmyra	101.6	101.1	101.7	101.5	101.48	2.1 B	101.3	101.5	101.9	104.6	105.4	***105.5***	105.1	...	***4.0***	***3.8***
14	Pansy	101.7	101.4	102.	100.9	101.50	2.0 B	102.	103.	103.9	***105.***	104.9	104.6	101.2	...	***3.4***	***3.0***
12	Bessie 2d	101.3	99.6	100.3	100	100.30	2.0 B	***104.1***	103.6	103.	102.6	102.	101.9	101.9	...	***3.3***	***2.8***
18	Colantha Rosa	101.9	101.4	101.9	101.2	101.60	1.75 B	101.8	102.1	101.8	162.6	103.	102.7	102.1	...	1.4	1.1
19	Exp'rimentalist	102.	102.1	102.	102	101.80	3.0 B	102.4	105.	***105.7***	103.6	103.9	104.9	105.4	103.8	***3.9***	***3.7***

Date of inoculation, Nos. 1, 4 and 9, on March 20; remainder on May 3. Lot I inoculated with imported tuberculin, Lot II with domestic material.

In this second test of the nine animals that were inoculated with imported tuberculin (Lot I) only two showed a reaction fever, while of the nine treated with Bureau tuberculin (Lot II), seven were diagnosed as diseased.

It was our original intention in making this cross series of injections, viz., inoculating Lot I with the imported tuberculin the first time and then repeating it with domestic product the second time and vice versa, to compare the two brands in their relative efficiency. Although the plan of the experiment was carried out the data cannot be used in this connection because the dose of the imported tuberculin administered was much below that which is ordinarily used.

The observations are, however, interesting because they show the effect that these extremely small doses (1-10 of the average minimal dose recommended) have upon the animals.

A comparison of the two tests will show some apparent discrepancies that need to be mentioned in this connection.

In two instances (Rue and Bunn), reaction temperatures were noted upon the second injection after they were declared healthy by the first. As the lapse of time between the two inoculations in these cases was seven weeks, it is possible that they might have contracted the disease during this interim, especially as they were kept under the same conditions as before with a herd, two-thirds of which were known to be tuberculous.

The autopsies of these two animals, made soon after the second injection, showed that the disease in Rue was well distributed, although not in an advanced stage, while that of Bunn pointed to a recent infection.

In several instances it will be noted that animals fail to react when inoculated the second time with the imported tuberculin that had reacted upon the first injection with the Bureau product. This evident discrepancy between the efficiency of the two brands, in picking out the diseased animals, can undoubtedly be explained. The failure

to produce a reacting temperature in those animals that had previously been diagnosed as tuberculous with the Bureau tuberculin is due to the minimum doses used. The Bureau fluid as injected is more concentrated than the imported product as used in the diluted condition by us, so that the amount of actual tuberculin introduced at the second injection was less than that which was used at the first. While an introduction of this same quantity sufficed to produce a reacting temperature in the first inoculation of an animal, yet this same amount introduced into an animal that had been previously inoculated with a stronger dose sometimes failed to produce the usual febrile symptoms.

Reference to Table 4 will show this point clearly. In those animals that were actually tnberculous, as demonstrated by *post mortems*, and which were first inoculated with the more concentrated Bureau tuberculin and then later with the dilute imported product, every case but two (Polly and Melvina), failed to show any reaction, while the dilute doses if administered first were confirmed by the second stronger injection in all but two cases (Bunn and Rue).

In these last cases there is the possibility mentioned above that they contracted the disease subsequent to the original injection. These facts taken in connection with the correct diagnosis of the eleven head of young stock (Lot III), where the very dilute doses were used, shows quite clearly that the failure to react in the above cases was due to the fact that the systems of the animals had been saturated, so to speak, with the stronger tuberculin and therefore they failed to react as a rule when a less amount was used at the second injection.

These experiments also show that the dose administered may be varied greatly and still produce a reaction in a diseased animal, for the amount of imported tuberculin that was injected was only one-tenth of the minimum dose that is usually recommended. The fact that this dose, as small as it was, produced a reaction in almost every diseased ani-

mal that received but a single injection indicates that smaller doses in these cases were quite as potent as the stronger injections. This question of dosage is one that needs to be investigated still further.

Taking the two tests in connection with each other the results may be summed up as follows: Thirty animals were inoculated in all; of these twenty-five reacted, showing a diseased state, the remainder being declared healthy.

AUTOPSY RECORDS.

To test the efficiency of this diagnosis it was necessary to slaughter the herd, especially those animals that had reacted to the test. At the same time it was just as essential that at least some of the healthy animals, as indicated by the test, should be killed in order to see if they might have the disease and still not react when injected with tuberculin.

Immediately after the completion of the second test the work of slaughtering began. The autopsies were conducted by Dr. Clark and the writer with the assistance in a few cases of Dr. Miller, Instructor in Anatomy in the University. The subjoined autopsy records are briefly given so as to indicate the extent of the disease in each case.

POLLY.—Grade Jersey; 18 months old.

History.—No trace of disease apparent, condition excellent, fat. Weight, February 20, 1894, 776 lbs.

Physical diagnosis.—Healthy.

Tuberculin test.—Marked reaction with both injections; February 20, Bureau tuberculin; March 22, imported brand.

Autopsy.—March 22; weight, 808 lbs. Left lung studded with small hard caseous tubercles, some of which were broken down into purulent matter. Submaxillary glands affected. Peritoneum over small intestine dotted with pearly protuberances, cheesy or calcareous.

Tubercles in lung seem to have developed with relation to circulatory system and not the bronchi. Bronchial glands healthy. Microscopical examination showed the infection to have been transmitted to the lymphatic circulation through the large follicles of mucous membrane of intestine.

DOUBTFUL.—Grade Jersey, 5 years old.

History.—Good.

Physical diagnosis.—Sound.

Tuberculin test.—Inoculated February 24 and May 2, 1894. No reaction in either case.

Autopsy.—May 9. No signs of tubercle on *post-mortem*.

GAY.—Registered Jersey, estimated 6 years old.

History.—Apparently healthy. Weight February 20, 871 lbs.

Physical diagnosis.—Suspicious, slight thickening of submaxillary lymphatics. Crepitation over portion of left lung. Increased respiratory murmur at lower end of trachea.

Tuberculin test.—February 20, reaction with domestic tuberculin. March 20, no reaction with imported tuberculin (only 28 days between injections).

Autopsy.—May 16, weight, 855 lbs. Single large abscess in intestinal wall (ileum). Several small pearly nodules on ileum and colon. Incipient tubercular spots in pharyngeal glands. Large, well-developed tubercle in right lung. Udder enlarged but flaccid, upon section tissue appears filled with small nodular masses, whitish in color. Few bacilli found in scrapings from inside of milk sinus.

AAGGIE NETHERLAND BEAUTY.—Registered Holstein, 5 years old.

History.—Animal always thin. Absolutely impossible to fatten when in lactation. Weight, February 22, 1,017 lbs.

Physical diagnosis.—Enlarged sub maxillary lymphatics, dullness on percussion over upper posterior part of right lung and slight crepitation. Suspicious.

Tuberculin test—Inoculated with Bureau tuberculin February 23. Strong reaction. Inoculated May 3 with imported tuberculin. Reaction 1.5 degrees Fahr.

Autopsy—May 12, weight 916 lbs. Pharyngeal glands filled with small tubercles, pin head in size. Mediastinal glands contain numerous small tubercles. Lesions apparently point to a recent infection.

GALENA.—Grade Jersey, estimated 5 years old.

Physical diagnosis.—Sound.

Tuberculin test.—Bureau tuberculin, February 23. Reaction. Imported tuberculin May 2. No reaction.

Autopsy.—May 12, weight 911 lbs. Pharyngeal glands affected. Small tubercles found in mediastinal glands, several pearly tubercles in ileum.

RUE OF SILVER SPRINGS.—Registered Jersey, 10 years old.

History.—Good. Weight, March 12, 980 lbs.

Physical diagnosis.—Enlarged submaxillary lymphatics. Dullness on percussion and slight crepitation over upper posterior part of right lung.

Tuberculin test.—Inoculated March 13, with imported tuberculin. Reaction of 1.8 degrees Fahr. Inoculated May 2, with Bureau tuberculin. Marked reaction.

Autopsy.—May 14. Weight, 880 lbs. Mediastinal glands cheesy and calcareous. Right and left lung show several small tubercles. Number of pearly nodules in ileum.

NETHERLAND NUGGET.—Registered Holstein, 3 years old.

History.—Good Weight, March 12, 1,122 lbs.

Physical diagnosis.—Suspicious. Submaxillary glands enlarged. Increased respiratory murmur over portions of each lung.

Tuberculin test.—Inoculated with imported tuberculin March 12. Reaction. With Bureau tuberculin May 2. Reaction.

Autopsy.—May 15, weight 958 lbs. Several pearly nodules in the wall of ileum. In right lung two or three tiny tubercles. In left lung several large pneumonic areas.

DAISY.—Grade Jersey, 14 years old.

History.—Animal thin and emaciated but poor condition seems to be a family trait, for two generations on mother's side were always thin: heavy milkers. Weight, Feb. 20, 778 lbs.

Physical diagnosis.—Tuberculous. Thickening of submaxillary lymphatics. Dullness of percussion over considerable area of each lung; husky cough; heaving of flank. Increased resonance over portion of left lung. Bronchial breathing over lower anterior portion of left lung. Emaciated. Hide bound.

Tuberculin test.— Inoculated February 20. Gave reaction. 2d injection with imported tuberculin March 20. No reaction.

Autopsy.—March 22. Anterior mediastinal gland slightly enlarged; showed a few small tubercles on periphery. Tissue examined microscopically and bacilli demonstrated. Other organs showed no evidence of tuberculosis. Dullness of percussion due to an old pleurisy, therefore the physical diagnosis as tuberculous not warranted by evidence at autopsy.

BUNN.— Grade Holstein, 11 years old.

History.—Good. Weight, March 12, 1,260 lbs.

Physical diagnosis.— Sound.

Tuberculin test.— Inoculated March 12 with imported tuberculin. No reaction. Bureau tuberculin May 2. Reaction 2.1 degrees F.

Autopsy.— May 15, weight 1,150 lbs. One tubercle in posterior lobe of left lung. Numerous pearls in the wall of ileum. Inflamed areas in pharyngeal glands

BEAUTY.— Native, estimated 12 years old.

History.— Good. Weight March 12, 1,120 lbs.

Physical diagnosis.— Dullness in percussion over posterior part of right lung. Bronchial breathing over lower anterior part of right lung. Probably tuberculous.

Tuberculin test.—March 12, imported tuberculin. Reaction 1.7 degrees F. May 2, Bureau tuberculin. Reaction 1.8 degrees F.

Autopsy.— May 17, weight 982 lbs. Shows a healed-over tubercle in left lung; also a single pearly nodule in intestine. Several well marked tubercles in anterior mediastinal glands.

BESSIE 2D.— Grade Jersey, 7 years old.

History.—Rather poor in flesh. Weight March 12, 930 lbs. About April 10 animal began to show signs of brain trouble and difficulty in standing or walking, ate but little. Weight April 12, 770 lbs. Milk decreased much in quantity (0.8 lbs per milking).

Physical diagnosis.—Suspicious. February 20, submaxillary gland slightly enlarged; crepitation over part of right lung.

Tuberculin test.— Reacted with imported tuberculin, March 13. Reacted upon second injection with Bureau brand, May 2.

Autopsy.— May 4, weight 694 lbs. Right lung diseased; showed a few large nodules, calcareous. Bronchial glands filled with numerous tubercles.

Marked changes in tissue of cerebellum although no bacilli could be demonstrated in sections of tissue.

PALMYRA.—Grade Jersey, 5 years old.

History.— Condition always good. Weight March 12, 906 lbs.

Physical diagnosis.— Given as sound. Slight crepitation over portion of right lung.

Tuberculin test.— Inoculated March 12, with imported tuberculin. Reaction. Second injection, May 2, with domestic tuberculin. Reaction.

Autopsy.—May 15, weight 821 lbs. All of mediastinal glands badly affected, cheesy and calcareous. One tubercle in posterior lobe left lung. Numerous pearly protuberances from wall of ileum.

PANSY.—Grade Jersey, 2 years old.

History.—Animal fat and in excellent condition. Weight 816 lbs., March 12.

Physical diagnosis.—Sound.

Tuberculin test.—Injected March 13. Reaction fever of 2 degrees above normal with imported tuberculin; although only 1.7° above highest normal. 2d injection with Bureau tuberculin, May 2, gave a strong reaction.

Autopsy.—May 4, weight 795 lbs. Bronchial glands filled with tubercles. A few well marked nodules in each lung. A well-defined but not a bad case. Lesions apparently recent.

COLANTHA ROSA.—Registered Holstein. 18 months old.

History.—Good. Weight 933 lbs., March 12.

Physical diagnosis.—Sound.

Tuberculin test.—Injected with imported tuberculin March 12. Strong reaction. 2d injection, May 2, with domestic tuberculin (only 1.75 cc. injected, a part of dose accidently lost). Rise in temperature of 1.4 degrees Fahr.

Autopsy.—May 10, weight 955 lbs. Only tuberculous tissue found in animal was in left posterior mediastinal gland, which had a few discrete tubercles.

MELVINA.—Registered Short Horn, 5 years old.

History.—Condition always good except a nasal catarrh which has been more or less severe for past three years. Weight 1,280, lbs. February 22.

Physical diagnosis.—Sound with the exception of above symptom.

Tuberculin test.—Bureau tuberculin, February 23. Marked reaction. Imported tuberculin May 2. Reaction.

Autopsy.—May 11, weight 1,240 lbs. Pharyngeal glands enlarged and calcareous. Mediastinal also contain numerous tubercles, many of which are broken down into abscesses. Numerous large abscesses and infiltrated areas in both right and left lung. Lesions point to an old chronic infection.

EXPERIMENTALIST.—Registered Jersey Bull. 3 years old.

History.—Presented when a young calf to the station by N. Y. Agricultural Experiment station. Weight 1,336 lbs., March 12.

Physical diagnosis.—Apparently sound, although detailed examination not made.

Tuberculin test.—Inoculated March 13, with imported tuberculin. Strong reaction. 2d injection with domestic tuberculin May 2. Reaction.

Autopsy.—Showed a badly affected chronic case. Pharyngeal and mediastinal glands well filled with calcareous tubercles. Both lungs showed numerous tubercles, hickory nut in size, imbedded in tissue; also several protruding from costal surface (grapes). Testis slightly affected.

LADY MOSSCOAT.—Short Horn. 2 years old.

History.—Daughter of Miss Cowslip 6th.

Tuberculin test.—Showed reaction of 2.7 degrees Fahrenheit.

Autopsy.—May 12. Mediastinal glands show a few small tubercles (pinhead in size). Acute inflamed areas in different lobes of both lungs. One or two small tubercles on ileum. Animal apparently infected recently by the way of the air passages.

MELROSE.—Short Horn. 18 months old.

Tuberculin test showed tuberculous condition of animal.

Autopsy — May 11. Mediastinal glands were completely infiltrated, calcareous, cheesy, and in some cases purulent. One tubercular abscess, size of walnut, in right lung; also several smaller tubercles with acutely inflamed tissue surrounding them. Left lung slightly affected; one pearly nodule on ileum.

PET.—Ayrshire, 16 months old.

History.—Perfectly healthy.

Tuberculin test.—May 10, injected with imported tuberculin; no reaction

Autopsy.—In right lung was found one small healed tubercle completely encysted in a fibrous capsule.

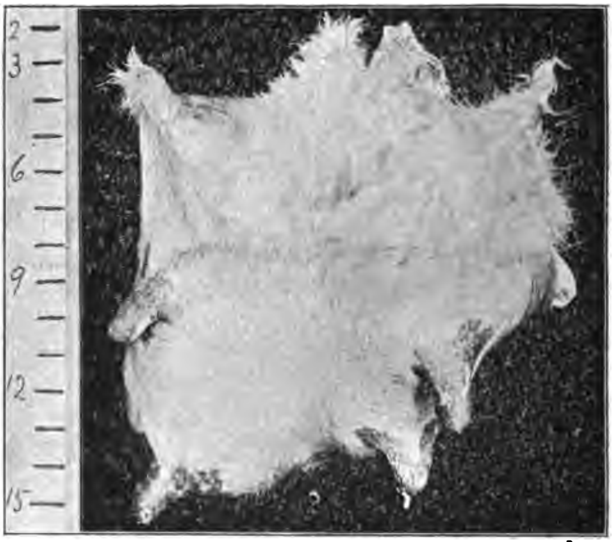


Fig. 20.—Front view of udder, showing relation of tuberculous hind quarter to the remainder of the organ.

Fig. 21.—Side view of tuberculous udder, showing tuberculous hind quarter much enlarged.

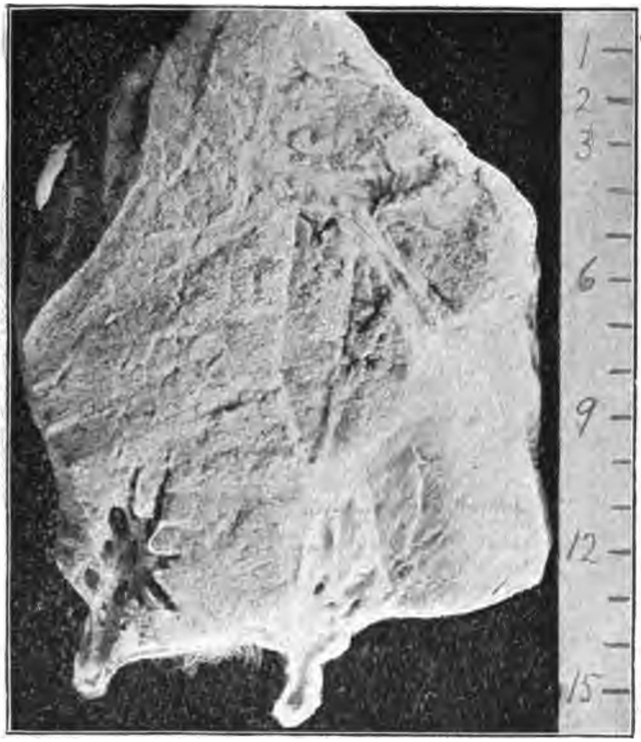


FIG. 22.—Section through udder of a tuberculous cow (Clothilde), showing diseased and healthy tissue. Right quarter, healthy, tissue soft, flaccid; left quarter very much enlarged (23 lbs.), hard, fibrous, full of tuberculous nodules.

CLOTHILDE ROSA.—Registered Holstein. 5 years old.

History.—Animal in good health until December, 1893. Calf dropped December 24. Weight at this time 1,150 lbs. Began to lose in flesh from this date. Swelling on udder noticed about January 20. Became emaciated very rapidly. Weight March 13, 1,077 lbs. Inoculated at this date with tuberculin. Died April 3.

Physical diagnosis.—Tuberculous. Enlarged maxillary glands; dullness and crepitation over upper part of left lung. Increased respiratory murmur at foot of trachea. Right hind quarter much enlarged and hard; mucous membrane pale; coat rough.

Tuberculin test.—Reaction fever present, although there was an abnormally high temperature before inoculation.

Autopsy.—April 3, weight 855 lbs. Abdominal peritoneal surface covered with net-work of fine tubercles following blood vessels. Peritoneum of wall covered with nodules. Bronchial glands much enlarged and filled with tubercles. Large clusters of nodules adherent to lungs and costal pleura (grapes) and also imbedded in tissue of lungs. Affected quarter of udder weighed 23 lbs.; a solid yellowish mass, calcareous, in few places. See Figures 20–22. Microscopical examination showed a very acute generalized stage of the disease; bacilli present in milk in very large numbers. This instance shows the effect of calving on animals already affected with tuberculosis.

FIG. 23.—Mesentery and small intestine of tuberculous cow. Numerous tiny nodules over surface of mesentery are tubercular in their character.

GALATEA.—Grade Jersey, 5 months old.

History.—Daughter of Galena and Experimentalist. Kept housed in same barn with other stock since birth. Apparently in good health.

Tuberculin test.—Inoculated May 2 with imported tuberculin; reaction.

Autopsy.—One small tubercle in left lung. Left mediastinal gland (posterior) showed a few discrete tubercles; bronchial glands possessed inflamed areas. Abdominal viscera healthy.

MELNOTTA.—Short Horn, 4 months old.

History.—Apparently in good condition, with the exception of a thickening between bones of lower jaw. Kept in stable with remainder of herd since birth.

Tuberculin test.—Injected with imported tuberculin, May 2; reaction.

Autopsy.—A large abscess enclosed in a fibrous capsule occupying space of pharyngeal gland. Mediastinal glands showed numerous tubercles some of which were calcareous and cheesy. Few small nodules in left lung. Intestines normal but mesenteric glands show numerous young tubercles.

ROSETTE.—Grade Jersey, 5 months old.

History.—Housed with herd since birth.

Tuberculin test.—Made with imported tuberculin, May 2; reaction.

Autopsy.—Incipient tubercles in right mediastinal gland; well developed masses in left mediastinal lymphatic glands. Slight nodular growths in a few of mesenteric glands; also numerous tiny tubercles in liver

Post-mortem appearances would indicate a mixed source of infection.

AUGUSTUS.—Holstein Bull, 6 months old.

Tuberculin test.—May 2, indicated tuberculosis.

Autopsy.—May 12. Right posterior mediastinal lymphatic full of small tubercles. Several pearly nodules on wall of ileum; also numerous young tubercles in mesenteric glands.

CHLOE.—Holstein, 4 months old.

History.—Daughter of Clothilde. Mother was tuberculous when with calf and rapidly wasted away with acute generalized stage of the disease. Udder markedly affected since calving.

Tuberculin test.—May 2, with imported tuberculin; reaction.

Autopsy.—May 12. Mesenteric glands filled with numerous nodules pin-head in size. Intestinal glands covered here and there with soft, young tubercles. Liver with several tuberculous areas scattered through tissue.

Unquestionably the calf must have been suckled on tuberculous milk from the very beginning.

JOSEPHINE.—Grade Jersey, 7 weeks old.

Tuberculin test indicated no disease.

Autopsy—May 12, showed no evidence of tubercular lesions.

NUGGET.—Registered Holstein, 6 months old.

History.—Housed in same barn with herd since birth.

Reaction with imported tuberculin. May 2.

Autopsy.—May 8. Superpharyngeal glands infiltrated and cheesy. Left anterior mediastinal studded with small hard tubercles. Several small tubercles in mesenteric glands.

BLOSSOM.—Grade Jersey, 5 months old.

History.—Housed with other animals.

Tuberculin test showed May 2 a strong reaction.

Autopsy.—May 12. Large abcess in pharyngeal gland. Mesenteric glands largely infiltrated with small-sized tubercles. Lungs healthy.

In order that a more comprehensive idea may be obtained of the different organs affected, their relative frequency, and also to bring out more clearly the probable source of infection, the autopsy records of tuberculous animals are arranged in a tabular form as follows:

TABLE 3.—*Showing distribution of disease in animals with probable source of infection.*

No.	NAME.	Age.	Breed.	Pharyngeal and submaxillary lymph glands.	Bronchial and mediastinal lymph glands.	Lungs.		Intestines.	Mesenteric glands.	Other organs.	Probable source of infection.	General remarks.
						Right.	Left.					
1	Polly	18 mos	Grade Jersey	T	T	......	T	T	......	......	......	Disease generalized, well developed.
4	Gay	6 yrs.	Jersey	T	......	T(1)	......	T	......	Ud'r T	Pulmonary	Widely distributed.
5	Aaggie	5 yrs.	Holstein	T	T	......	......	......	......	......	Pulmonary	Incipient stage.
6	Galena	5 yrs.	Grade Jersey	T	T	......	......	T	......	......	Pulmonary	Incipient stage.
7	Rue	10 yrs.	Jersey	......	T	T	T	T	......	......	......	Well developed case.
8	Neth. Nugget	8 yrs.	Holstein	......	......	T	......	T	......	......	Enteric	Tubercles in lungs partially encysted.
9	Daisy	14 yrs.	Grade Jersey	......	T(1)	......	......	......	......	......	Pulmonary	Chronic case, localized.
10	Bunn	11 yrs.	Grade Jersey	......	......	......	T(1)	T	......	......	Enteric	Udder glands greatly enlarged.
11	Beauty	12 yrs	Native	......	T	......	T(1)	......	......	......	Pulmonary	Tubercle in lung encysted.
12	Bessie 2d.	7 yrs.	Grade Jersey	......	T	T	......	......	......	Liv. T	Pulmonary	Acute in lungs; serious brain lesions.
13	Palmyra	5 yrs.	Grade Jersey	......	T	......	T(1)	T	......	......	Pulmonary	Chronic.
14	Pansy	2 yrs.	Grade Jersey	......	T	T	T	......	......	......	Pulmonary	Well defined but recent case.
15	Melvina	5 yrs.	Short Horn	T	T	T	T	......	......	......	Pulmonary	Numerous abscesses in lung; old case; bad.
17	Clothilde Rosa	5 yrs.	Holstein	......	T	T	T	T	T	Ud'r T	......	Acute generalized case; tuberculous throughout.
18	Colantha Rosa	19 mos	Holstein	......	T	......	......	......	......	......	Pulmonary	Recent infection.
19	Experim'ntalist	8 yrs.	Jersey bull	T	T	T	T	......	......	Testis T	Pulmonary	Bad case; chronic.
20	Lady Mosscoa	2 yrs.	Short Horn	......	T	T(1)	T	T	......	......	Pulmonary	Acute type; recent.
21	Melrose	18 mos	Short Horn	......	T	T	T	T(1)	......	......	Pulmonary	Well developed case.

TABLE 3—Continued.

23	Galatea........	6 mos	Grade Jersey.	....	T	....	T(1)	....	......	....	Pulmonary...	Recent infection.
24	Melnotta........	4 mos	Short Horn...	T	T	. ...	T	....	T	....	Pulmonary...	Large abscesses in pharyngeal lymph gland
25	Rosette.........	5 mos	Grade Jersey.	....	T	T	......	... .	T(1)	Liv. T	Mixed	Thoracic cavity badly affected.
26	Nugget.........	5 mos	Holstein . ..	T	T	....	....	....	T	....	Mixed	Strongly developed in thorax.
27	Blossom........	6 mos	Grade Jersey.	T	... .	....	....	....	T	. ...	Mixed	Abscesses in pharyngeal lymphatics.
28	Augustus.......	6 mos	Holstein......	....	T	....	....	T	T	.. ...	Mixed.	Incipient case.
29	Chloe...........	4 mos	Holstein.... .	....	T	....	......	T	T	Liv. T	Enteric.......	Derived from suckling diseased mother.
	Per cent. of cases in which various organs were diseased.................			36 p. ct.	81 p. ct.	44 p. ct.	52 p. ct.	48 p. ct.	28 p. ct.			
	Per cent. where lungs were affected			....		68 p. ct.						
	Per cent. showing infection by air passages and intestinal canal.................. ..			100 p. ct.				64 p. ct				

(1) A single tubercle found in affected organ.

Comparison of autopsy record with diagnosis made by tuberculin (see Table 4) will show that in every one of the twenty-five animals diagnosed as diseased, evident tuberlar lesions were found. Of the five animals that did not react three were killed, and in one instance (Beauty) a well developed tuberculous condition of the anterior mediastinal lymphatics was observed.

This is, then, the only failure recorded against the tuberculin test in this herd.

COMPARISON OF PHYSICAL WITH TUBERCULIN TEST.

The efficiency of the tuberculin test over the physical diagnosis is well seen in the case of this herd. In the incipient stages of the malady it is practically impossible to detect the diseased condition of the animal, especially if it develops in connection with the alimentary tract.

Dr. Clark made a careful physical examination of the animals, eighteen in number, included in Lots I and II. His report is embraced in the table found on following page, and the details of the examination are grouped with the *post mortem* accounts in the foregoing autopsy notes.

TABLE 4.—*Résumé comparing physical examination and tuberculin test with post-mortem results.*

No.	Name.	Physical diagnosis.	Reaction in Degrees Fahr.		Autopsy record.	Diagnosed Correctly by	
			With bureau tuberculin.	With imp. tuberculin.		Phys. exam.	Tuberculin test.
1	Polly	Sound	*4.8*	*a2.9*(2)	Tuberculous	−	+
2	Bessein	Sound	1.6	1.4(2)	Not killed	....	....
3	Doubtful	Sound	1.7	0.8(2)	Healthy	+	+
4	Gay	Suspicious	*3.4*	0.6(2)	Tuberculous	+	+
5	Aaggie	Suspicious	*4.3*	1.5(2)	Tuberculous	+	+
6	Galena	Sound	*3.7*	0.8 (2)	Tuberculous	−	+
7	Rue	Tuberculous	*3.5*(2)	1.6	Tuberculous	+	+
8	Neth. Nugget	Suspicious	*3.5*(2)	*2.8*	Tuberculous	+	+
9	Daisy	Tuberculous	*3.0*	1.1(2)	Tuberculous	−	+
10	Bunn	Sound	*2.1*(2)	0.6	Tuberculous	−	+
11	Beauty	Tuberculous	1.3(2)	1.6	Tuberculous	−	−
12	Bessie 2d	Suspicious	*3.8*(2)	*3.1*	Tuberculous	+	+
13	Palmyra	Sound	*4.0*(2)	*3.6*	Tuberculous	−	+
14	Pansy	Sound	*3.4*(2)	*2.0*	Tuberculous	−	+
15	Melvina	Sound	*4.4*	*2.0*(2)	Tuberculous	−	+
16	Cowslip	Sound	1.2	1.4(2)	Not killed	....	....
17	Clothilde Rosa	Tuberculous	*b*	*2.9*	Tuberculous	+	+
18	Colantha Rosa	Sound	c1.4 (2)	*4.6*	Tuberculous	−	+
19	Experimentalist	Not examined	*3.9* (2)	*5.1*	Tuberculous	....	+
20	Lady Mosscoat	Not examined	....	*2.8*	Tuberculous	....	+
21	Melrose	Not examined	....	*4.7*	Tuberculous	....	+
22	Pet	Not examined	....	0.0	Healthy	....	+
	CALVES.						
23	Galatea	Not examined.	....	*2.6*	Tuberculous	....	+
24	Melnotta	Not examined	....	*3.8*	Tuberculous	....	+
25	Rosette	Not examined	....	*3.1*	Tuberculous	....	+
26	Nugget	Not examined	....	*3.8*	Tuberculous	....	+
27	Blossom	Not examined	....	*4.4*	Tuberculous	....	+
28	Augustus	Not examined	....	*2.5*	Tuberculous	....	+
29	Chloe	Not examined	....	*3.1*	Tuberculous	....	+
30	Josephine	Not examined	....	0.0	Healthy	....	+
					Ratio of cases diagnosed correctly	7:16	27:28

a Figure two enclosed in parenthesis as such (2) indicates the second inoculation.
b Animal died before second inoculation.
c Through an accident a part of dose was lost, hence no reaction fever indicating disease.

In only two cases (Daisy and Clothilde Rosa) did he find marked symptoms that led him to pronounce the animals undoubtedly tuberculous. Two other animals were also diagnosed as diseased, although the symptoms were less marked, and four animals were noted as suspicious.

Reference to table 4 will show the instances in which the physical diagnoses were confirmed by the autopsy. Of the two animals that were regarded as unquestionably diseased one showed a generalized tubercular condition strongly manifested in the udder. The other animal (Daisy) was slightly tuberculous (one lymph gland), but an old pleurisy had misled the veterinarian in his physical examination. If the tuberculous animals that were diagnosed as suspicious are regarded as correctly diagnosed, then the veterinarian succeeded in the physical examination in seven out of sixteen cases. The remainder of the herd that was later subjected to the tuberculin test was not closely examined by the veterinarian, but all of the animals were in apparent good health as far as could be noted upon a cursory examination. The superiority of the Koch test over a physical examination is thus demonstrated beyond all doubt.

If tuberculosis is a disease that should be eradicated because it is a menace to public health and to successful animal industry, we must be able to recognize it in its earlier stages as well as the more advanced cases. By means of the physical examination alone, this is manifestly impossible, but by the aid of the tuberculin test, we can at once determine in almost every instance whether the disease is present even in its earliest phases.

The objection is often urged that the tuberculin test is too delicate, that it detects a diseased condition before any danger can possibly arise from it. This objection is, in fact, one of the strongest points in its favor, for it enables a dairyman to know the actual condition of his herd, and to take such precautionary measures that will enable him to limit the possible spread of the disease.

In the course of the past season several other herds have also been tested with tuberculin. The complete temper-

ature readings of the total number of animals injected will not be given but only those cases that are of especial interest.

RESULTS WITH HERD II.

Herd II owned by B. C. was composed of twenty animals, five of which were registered Guernseys, ten high grade Guernseys and five grade Jerseys. All of the animals in this herd except a registered cow and bull were bred and raised on the farm. The history of the herd in the past has been good, no deaths having occurred for ten years. Tuberculosis has never been suspected. The physical examination made by Dr. Clark showed no disease whatever. The inoculations were also made by him.

Of the twenty animals that were injected only five were at all suspicious. The reaction with the remainder of the herd varied from 0.2° F. — 1.5° F. so that they were not regarded as reaction fevers. The records of the five animals that should be more closely scrutinized are as follows:

TABLE 5.—*Ante-inoculation temperature records.*

No.	NAME.	Breed.	Age.	NORMAL TEMPERATURES. VII. 20. 7 A. M.	VII. 20. 7 P. M.			
36	Kate	Gr. G...	6 yrs ...	101.5	103.3			
40	Nancy.......	Gr. J....	6 yrs.....	100.8	101.6			
				VII. 23. 5 A. M.	VII. 23. 12 M.	VII. 23. 7 P. M.	VII. 24. 7 P. M.	VII. 25. 7 A. M.
43	Kit............	Gr. G...	3 yrs....	100.4	101.4	102.5	102.9	101.7
47	Nan...........	Gr. G...	2½ yrs..	99.8	101.4	102.3	102 6	101.8
48	Julia...... ...	Gr. G...	6 yrs. ..	100.	101.6	102.	102.5	101.4

Post-inoculation temperature records.

No.	Average normal.	JULY 21. 4 A. M. (8 hrs.)	6 A. M. (10 h's.)	8 A. M. (12 h's.)	10 A. M. (14 h's.)	12 M. (16 h's.)	3 P. M. (19 h's.)	6 P. M. (21 h's.)	Reaction above average normal.	R'action above highest normal.
36	102.4	101.9	101.9	102.2	102.3	102.3	102.8	103.2	0.8	—0.1
40	101.2	100 3	102.1	102.4	104.2	***104.8***	103.	102.4	***3.6***	***3.2***
		JULY 25. 3 P. M. (8 hrs.)	6 P. M. (11 hrs.)	8 P. M. (13 hrs.)	10 P. M. (15 hrs.)	1 A. M. (18 hrs.)				
43	101.8	103.6	103.8	102.8	102.3	102.3			2.0	0.9
47	101.6	103.6	***104.2***	103 4	101.7	102.2			***2.6***	***1.6***
48	101.5	103.2	103.4	102.4	102.	101.8			1.9	0.9

In the above cases Nos. 40 and 47 (Nancy and her calf Nan) are unquestionably tuberculous. In all probability Nan contracted the disease by suckling her diseased mother. The remaining cases are not so easy to diagnose from the data at hand.

As No. 36 (Kate) was due to calve in about one month, her variation in temperature before inoculation may be ascribed to her pregnant condition. It is plainly evident that

her average normal as given is much too high, so that the total reaction is considerably less than it should be. Then again it will be observed that the temperature of this animal was rising when the observations were stopped. Where such a condition is found, it is always necessary to continue to take temperatures until they begin to decline. Usually the maximum febrile reaction occurs in the course of twenty hours, but it sometimes happens that the highest temperature is found after this lapse of time. (See cases of Experimentalist, No. 19, and Clothilde Rosa, No. 17, Table 1 B, page 170.

In the cases of Kit (No. 43) and Julia (No. 48) there was a rise above average normal of 2.0° F. and 1. 9° F. respectively, and above the highest normal of only 0. 9° F. in each case. In both cases the highest inoculation temperature occurredat 6:30 p. m., approximately the same time of day that registered the maximum normal of the two preceding days. This might indicate that the maximum inoculation temperature was merely an exaggerated diurnal rise, and not sufficient to be called reaction. Then again, the average normal, as given in this case is higher than it really should be, for it contains the evening (the highest) temperatures of two days. If the average of the normals of 5:30 a. m., 12 m. and 7 p. m. of July 23 (one full day) is taken instead of the whole series, the average normal temperature of the animals in question will be lowered from 0.3°—0.4° F., thus increasing the extent of the reaction above the average normal in both cases to 2. 2° F. and over. This rise in temperature would be sufficient to warrant the diagnosis as exceedingly suspicious. On the strength of these results, isolation and quarantine was recommended with a subsequent test to be applied later. At date of writing no autopsies have been made so that the correctness of the diagnoses in these cases is not definitely known.

RESULTS WITH HERD III.

Herd III owned by G. C. H. & Son is a herd of full blooded and high grade Guernseys that was also tested

by Dr. Clark August 31st. In this instance the imported tuberculin was used.

In this herd of twenty-three head, twenty-two of which are full blooded, only one animal, a seven year old cow No. 57 was found that gave a reaction indicating the presence of the disease. In the case of a two months' old calf, No. 72, the temperature closely approximated a reaction, although this diagnosis was not made in this case.

With the remainder of the herd the post-inoculation temperatures ranged from 0.1° F. – 1.55° F. above average normal.

The temperatures of the two animals that are of most interest are as follows:

TABLE NO. 6.—*Temperature records.*

ANTE-INOCULATION.				POST-INOCULATION.					REACTION ABOVE	
No.	Aug. 30, 7 p. m.	Aug. 31, 7 a. m.	Average normal	August 31. 4 p. m.	August 31. 7 p. m.	August 31. 9 p. m.	August 31. 11 p. m.	Sept. 1. 2 a. m.	Average normal	Highest normal
57	102.	102.2	102.1	103.3	105.1	*106.*	105.7	104.7	*3.9*	*3.8*
72	102.9	101.4	102.15	102.9	104.1	103.8	102.9	102.6	2.0–	1.2

No. 57 gave a very evident reaction and was consequently diagnosed as diseased. On November 2d this cow was slaughtered and found to be tuberculous, thus confirming the diagnosis by the test. At the autopsy the udder was found to be diseased, a large abscess being present that was filled with broken down purulent material. Abscesses were also demonstrated in the lungs, together with tubercles of a caseous nature.

The condition of the young calf, No. 72, was not considered as tuberculous, although the rise in temperature at one time was quite marked. It will be noted that the maximum inoculation temperature occurred at the same hour as the maximum normal and was only 1.2° F. above it. The duration of this rise was so short that it can hardly be called a reaction fever and should doubtless be considered as a temporary variation.

No. 57, which had been taken by the owner on shares, had been introduced into this herd but a short time before. Fortunately the tuberculin test revealed the true condition of the new accession, and the herd was probably saved from a further spread of the disease.

The two herds considered above were almost all high grade or registered stock of the Guernsey breed. In neither case was the disease very severe, although in both instances it was present in the herd, and having obtained a foothold the danger of further infection was possible.

In view of the fact that the great majority of the tuberculin tests have been made upon graded or registered stock, it would seem desirable if data on native or common stock could also be secured.

The theory is often advanced that tuberculosis is far more prevalent among the finer breeds than it is with native or low grade stock, but experiments with tuberculin upon this class are altogether too few, as yet, to make any sweeping generalizations.

RESULTS WITH HERD IV.

This herd belonging to E. F. R. had a large proportion of common native cows and on this account the results obtained are of interest. In the herd of twelve animals, Nos. 74 to 85 inclusive, eleven of which were cows, five were common native cattle, the remainder being low grades of the Jersey, Holstein and Short Horn breeds, with the exception of one cow which was a high grade Short Horn.

The history of the herd has been a good one, no deaths having occurred for a number of years. Almost all of the cows had been raised on the farm excepting three that had been brought to the place with a change of tenants four years ago.

The herd was tested on August 30th and 31st by the writer, using the bureau tuberculin. Five ante-inoculation temperature readings were taken to obtain an average nor-

mal. The post-injection temperatures ranged from 0.4° F. to 1.4° F. above this normal so that no reaction was found and the herd was declared free from the disease.

In addition to these four herds which included eighty-five animals a few isolated cases were also tested with tuberculin, bringing the whole number up to ninety-two. A brief recapitulation of the results obtained in these cases is as follows:

TABLE 7. –*Summary of inoculations.*

No. of herd.	No. of animals tested in each herd.	No. diagnosed as diseased by test.	No. found diseased at autopsy.	Failures in diagnoses.
I	30	25	26	1
II	20	4	....	....
III	23	1	1	0
IV	12	0	....	....
V*	8	0	....	....
	93	30	27	1

* Isolated cases are included under Herd V.

CONCLUSIONS.

In the above series of inoculations only one failure (Beauty of Herd I, Station) is to be recorded against the tuberculin test. Every animal diagnosed as diseased by the test was found to be tuberculous when slaughtered. In only this single instance was a tuberculous animal found that had given no reaction when inoculated.

Of the entire number of animals (30) that the test condemns as diseased only seven of these had been recognized as tuberculous upon the basis of a physical examination.

Our experience with the tuberculin test has been eminently satisfactory as it has enabled us to detect five times the number of cases that were discoverable by the ordinary method of examination.

Errors are sometimes found in the tuberculin test even where it is used with the greatest of care. These mistakes, however, are rarely due to the imperfect action of

the tuberculin but in the great majority of cases, failures in diagnoses are the fault of the operator rather than the agent used. As experience with this agent increases it may be expected that these personal errors will be reduced to a minimum.

In recommending the test as a diagnostic agent, there is one point the importance of which is often underrated, and that is the necessity of securing a full set of the ante-inoculation temperature readings. The normal temperatures of cattle are subject to such marked fluctuations that unless abundant data in each case are secured, many instances will occur in which it is impossible to make an accurate diagnosis. It is, of course, desirable in introducing the test in a practical way to reduce the amount of work to the minimum, as far as time is concerned, but a reduction in the number of preliminary temperature readings is often made at the expense of accurate diagnosis. In the majority of instances, the reaction fever will doubtless be so marked that slight variations from the average normal will not affect the result, but often the total reaction so closely approximates the minimum limit that is taken to represent a tuberculous condition that the operator is sometimes misled, unless he has a series of normals extending over at least a full day.

An instance of this sort is seen in the case of Nos. 43 and 48, mentioned on page 190. With the data at hand, these cases can only be pronounced suspicious, but if a full set of normals had been secured so as to determine the daily variation, a positive diagnosis could no doubt have been made.

Our knowledge concerning the normal variation in the temperature of cattle and the causes that induce the same is yet too vague and imperfect to deduce any well defined laws. As the use of tuberculin is extended this phase of the subject must demand greater attention. In conclusion, the results already accomplished with it warrant its continued use as the best means of detecting tubercular troubles in cattle.

THE INFECTIOUSNESS OF MILK FROM TUBERCULOUS COWS.

H. L. RUSSELL.

It is becoming more and more evident as the use of tuberculin increases that the percentage of dairy cattle affected with this disease is larger than was formerly supposed. Recent reports from Denmark and Germany, where the tuberculin test has been most thoroughly tried, show an alarming amount of it among dairy stock, and here in this country in a great many of the best dairy herds it has obtained a strong foothold. These facts that are brought out by the use of tuberculin raises anew the question concerning the infectious properties of the milk from tuberculous animals.

Experiments upon this question are as yet conflicting in their results. The opinion of Koch, based upon his experiments, that the bacilli were only present in the milk when there was a demonstrable lesion of the disease in the udder was for a long time accepted as correct. Since these experiments were made, numerous investigators have considered the same question. Nocard, McFadyean, Law and others failed to infect experimental animals when the milk of tuberculous cows with healthy udders was used. On the other hand, Hirschberger, Bollinger, Bang, Ernst, Smith and Kilbourn have shown experimentally that tuberculous animals deliver infectious milk even though the disease may not be present in the lacteal organs.

In view of the fact that the experimental evidence at hand is of such a contradictory nature, it would seem that all the data that can be accumulated on this subject is desirable. The recent introduction of tuberculin as a means

of diagnosing this disease facilitates work of this character. Then, too, the fact that the majority of tuberculous cows are now slaughtered when their diseased condition is ascertained makes it possible to determine accurately the condition of the udder. In many of the previous experiments that have been made on diseased animals with supposedly healthy udders, the diagnosis concerning the condition of the udder has been based merely upon external examination. Where autopsies are held the actual distribution of the disease can be accurately determined and consequently the data gathered in this way is more valuable on the point in question.

INOCULATION EXPERIMENTS WITH MILK, ETC.

In the severe epidemic of tuberculosis that we experienced with the Station herd, the opportunity was offered for a study of the milk with reference to this question. At the time these experiments were instituted only one animal, Clothilde Rosa, showed any evident udder lesions that were of a tuberculous character.

Table I gives a résumé of the experiments made with milk inoculated into rabbits and Guinea pigs from a number of the animals of the herd that were known to be tuberculous as diagnosed by the Koch test. In some cases the fresh milk was injected; in others the milk was received with the greatest possible care in sterilized Erlenmeyer flasks. The contents were then centrifuged and the sediment in the bottom of the flask used for inoculation.

TABLE I.—*Results of the inoculation of milk from tuberculous animals in experimental animals.*

Experimental animal.	Date of inoculation.	Material and quantity inoculated.	Source of inoculated material.	When killed or died.	Autopsy.
Rabbit No. 1	February 28	2 cc. milk	Daisy	March 22	Diffused infiltration in liver, no tubercles.
Rabbit No. 2	February 28	1.5 cc. milk	Daisy	June 26	Accidental death, no evidence of tubercles.
Rabbit No. 3	February 28	3 cc. sediment	Daisy		Still healthy, May 1, 1895.
Rabbit No. 4	February 28	1 cc. sediment	Aaggie	June 20	No evidence of tubercles.
Rabbit No. 5	February 28	2 cc. milk	Aaggie	Aug. 25	No signs of tuberculosis.
Rabbit No. 6	February 28	4 cc. milk	Aaggie	March 20	Accidental death, no tubercles on autopsy.
Rabbit No. 7	March 13	2 cc. milk	Clothilde	May 7	*Whole abdominal viscera covered with tubercles, lungs infiltrated.*
Rabbit No. 8	March 3	1 cc. milk	Clothilde	June 25	*Cutaneous lymph glands tuberculous, lungs solid cheesy mass.*
Rabbit No. 9	May [illegible]	1.5 cc. milk	Gay	Oct. 7	No tuberculosis.
Guinea pig No. 2	May 1[illegible]	2 cc. sediment	Galena	Oct. 10	Intestinal trouble induced by overfeeding. No tubercles present.
Guinea pig No. 3	May 1[illegible]	0.5 cc. sediment	Galena	July 14	No tuberculosis present at autopsy.
Guinea pig No. 4	May 1[illegible]	2 cc. sediment	Galena	May 15	Septic infection.
Guinea pig No. 5	May 15	1.8 cc. sediment	Bunn		Still healthy, May 1, 1895.
Guinea pig No. 6	May 15	1.3 cc. sediment	Bunn	May 16	Death due to septic infection.
Guinea pig No. 7	May 15	1 cc. sediment	Bunn	Oct. [illegible]5	No tubercles.
Guinea pig No. 8	May 15	2.0 cc. milk	Neth. Nugget	July 3	Peritonitis, no tubercles.
Guinea pig No. 9	May 20	0.5 cc. milk	Neth Nugget	Aug. 20	No tuberculosis present.

From the above table it will be noted that the milk of only one animal, Clothilde, was able to infect experimental animals when injected directly into the abdominal cavity. Rabbit No. 7 was inoculated with 2 cc. of the milk and died from tuberculosis in the course of 55 days. Rabbit No. 8 inoculated with only a single cubic centimeter died in just twice the time (110 days). At the time when the milk from this animal was inoculated, the udder was badly swollen, the growth being of a hard, dense character and painless. A microscopic examination of it also revealed the presence of numerous tubercle bacilli.

AUTOPSY RECORDS SHOWING EXTENT OF TUBERCULOSIS IN COWS.

In this connection reference to the autopsy notes of the animals mentioned in the above table will be of service in determining the extent to which the various cows were diseased. These records will be found in detail in another connection on page 176, also summarized briefly in table 3, on page 184. From these it will be seen that the disease in Daisy, Aaggie, Galena and Netherland Nugget was either localized or in an incipient stage, so that it is highly improbable that their milk would be affected in any way.

With the three remaining animals, the autopsy records reveal a more suspicious condition. The udder glands of Bunn were greatly enlarged, although tubercular areas were not demonstrated. In Gay the udder was enlarged and bacilli were sparsely found in scrapings from the walls of the milk sinus, but in the rabbit inoculated with her milk no trace of tubercular affection was demonstrable.

In Clothilde the udder lesions were very pronounced and bacilli were determined in the milk in abundance. Both of the experimental animals inoculated with her milk succumbed to the disease inside of two to four months.

CONCLUSION.

From these limited experiments, the conclusion in this case seems warranted that the milk from these tuberculous animals was not infectious where the disease was not localized in the udder. Even where the udder was possibly affected, the bacilli were not present in the milk in sufficient quantities to call forth a diseased condition in the susceptible animal inoculated with small quantities (1—4cc.), except in a single instance where the animal had the disease in an aggravated form. These results add somewhat to the data on this subject, but the amount of evidence must be considerably augmented before definite conclusions are drawn as to the infectiousness of milk from tuberculous animals where the disease does not affect the udder.

RELATION OF SEPARATOR SLIME TO TUBERCULOSIS IN HOGS.

H. L. RUSSELL.

Ostertag[1] has pointed out the interesting coincidence between the development of the separator process of creaming and the spread of tuberculosis among swine in Europe. In north Germany and Denmark where the centrifugal method is extensively used to separate the cream from the milk, the percentage of tuberculous hogs is very much greater than it is in the southern parts of Germany where swine are fed on the skim milk raised by the gravity process. In the northern countries the refuse creamery products (skim milk and separator slime) are fed in a comparatively fresh condition.

Scheurlen[2] and others have pointed out the peculiar relation that the tubercle bacillus bears to the centrifugal process. They have shown that this germ goes largely with the slime so that the sediment adhering to the separator bowls that is derived from milk coming from tuberculous cows often has infectious properties. As this slime possesses a large amount of proteid materials, and therefore has considerable nutrient value, it is often fed to hogs. The relation above referred to is certainly possible and well worth being made the subject of further study.

The experiment detailed below was suggested by the above facts.

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[1] Milch Zeitung 22, p. 672.

[2] Arbeiten aus d. Kais. Gesundheitsamte, 7, (1891) 269.

FEEDING EXPERIMENT.

A litter of four pigs, 6 weeks old, was taken and divided into two lots. Lot I (Nos. 1625 and 1627) was fed on a ration consisting of skim milk and dry feed (one-half shorts and the remainder corn meal), while Lot II (Nos. 1624 and 1626) was given the same ration and to this was added the separator slime from the University creamery. The amount of slime secured from the daily run of 3,500–4,000 lbs. of milk was rather small, averaging about seven to eight pounds per week. The experiment was begun on August 23 and continued without intermission until November 10. During this time the amount of feed consumed was as follows:

	Skim milk.	Dry feed.	Slime.	Total feed.
Lot I	1,159	321	....	1,480
Lot II	1,185	330	86.5	1,601.5

The amount of slime consumed by the two pigs in Lot II was by weight 5.4 per cent. of the entire amount of food consumed.

AUTOPSY RECORDS.

On November 13, the young pigs were killed. The following post mortem records show their condition:

Lot I.

Pig No. 1625. Weight 111 lbs. All internal organs in thoracic (lung cavity) and abdominal regions entirely free from disease.

Pig No. 1627. Weight 85 lbs. This animal appeared to be stunted in its growth from the very first. Careful examination of all lymph glands, lungs and intestines failed to show any evidence of tubercular troubles. Perfectly healthy throughout.

Lot II.

Pig No. 1624. Weight 107 lbs. Lungs, lymph glands and intestines entirely free from disease. Liver tissue especially on surface studded with small whitish areas of a diffused character, apparently of a fibrous nature. These patches not of a tubercular character.

Pig No. 1626. Weight 101 lbs. Autopsy revealed the same condition in liver as in No. 1624. All other organs perfectly healthy.

Samples of liver tissue from Nos. 1624 and 1626 were submitted to Dr. W. S. Miller, anatomist in the University, for a more detailed miscrocopic examination. He reported that there was an abnormal development of the connective tissue lying between the liver lobules (smooth cirrhosis) in both cases. This condition is usually associated with over feeding.

As both of the pigs that had been fed on slime developed this condition, and as the two controls were free from it, the inference is natural that the slime was associated with it in some way. Separator slime has an extremely high nitrogenous content (26 per cent. crude protein according to Fleischmann) so that the ration used with the slime fed pigs would be much richer in nitrogen than with the controls. A calculation of the total amount of digestible protein fed in the case of each lot shows that Lot II (slime fed) received almost a third more crude digestible protein than Lot I. This was almost all contained in the slime used in the feed. This variation certainly is a marked one and needs further experiment before a definite answer can be given.

CONCLUSION.

This experiment while limited in its application on account of the small amount of slime used approaches natural conditions as they would exist where swine are fed on the waste products from any given creamery, for, if the whole yield of slime from any creamery having run of

even 15,000 lbs. daily was fed to a drove of hogs, it is not probable that the amount per animal would exceed the amount used in this experiment. The above experiment although negative in its results as far as tuberculosis is concerned shows that the slime from the creamery tested when fed in proportion indicated above did not possess infectious properties when introduced into the digestive tract of the animal.

TESTS OF DAIRY COWS.

J. W. DECKER.

During the past four years this Station has been frequently called upon by breeders and agricultural associations to make tests of cows. Whenever possible to make such tests without interfering with other Station duties the requests have been granted, the writer being detailed for the work in the majority of cases. In all over 90 tests, varying in length from one to seven days, have been made. The result of these, averaged for a single day in each case, are given in the following table, in which the cows of each breed are grouped together according to age.

TABLE 1.

Table showing average test for one day of individual cows, arranged according to breed and ages of animals.

Owner.	Address.	Name of cow.	Age.	Days in lactation.	Av. milk per day.	Av. fat per day.	Av. fat per day.	No. of days tested.
1—Jerseys.			Ye'rs		Pounds.	Per cent.	Pounds.	
A. L. Grengo	Colgate	Sunday Night	2	....	12.5	5.2	.65	3
C. B. Miller & Co	Madison	Ida Pogis	2	252	9.85	5.62	.53	5
N. N. Palmer & Son	Brodhead	Gold Flier	3	151	20.1	4.72	.95	2
Victor Lowe	Palmyra	Koffees Lady Pogis	3	....	20.5	5.17	1.06	2
Victor Lowe	Palmyra	Koffees May Belle	3	....	19.0	5.40	1.03	2
N. N. Palmer & Son	Brodhead	Fannies Fairy	3	119	18.45	6.88	1.26	1
N. N. Palmer & Son	Brodhead	Fannies Fairy	5	73	31.2	5.35	1.67	3
C. B. Miller & Co	Madison	Callie Logan	3	90	21.6	4.77	.93	2
Victor Lowe	Palmyra	Rubina Love	4	....	19.8	5.15	1.02	2
Victor Lowe	Palmyra	Ouachette 3rd	4	....	23.3	5.79	1.35	1
N. N. Palmer & Son	Brodhead	La Ceres	4	172	36.1	4.29	1.55	2
R. S. Kingman	Sparta	Lillie of Sparta	4	98	14.55	6.05	.88	5
C. B. Miller & Co	Madison	Annie Johnson	4	116	12.95	6.87	.89	5
C. B. Miller & Co	Madison	Neata Bullard	4	179	13.45	6.17	.53	5
Wm. Shanks	Alloa	Princess Beatrice	4	....	18.13	5.07	.92	1
Wm. Shanks	Alloa	Princess Helen	4	....	16.63	7.16	1.19	1
Victor Lowe	Palmyra	Rubino's Quachette	5	....	15.8	4.62	.73	2

N. N. Palmer & Son	Brodhead	Madora Gold	5	120	30.1	5.41	1.63	3
C. B. Miller & Co	Madison	Louis Grace	6	37	27.24	4.19	1.14	5
C. B. Miller & Co	Madison	Dame Rhoda	6	50	20.5	6.27	1.29	5
R. S. Kingman	Sparta	Pet Pedro	6	52	31.8	6.13	1.95	2
R. S. Kingman	Sparta	Linda Pedro	6	142	28.6	6 33	1.81	2
R. S. Kingman	Sparta	Linda Pedro	8	85	32.6	6.20	2.02	2
R. S. Kingman	Sparta	Riotera Pogis	6	62	29.9	5.08	1.52	2
R. S. Kingman	Sparta	Pluma Pedro	6	....	25.8	5.58	1.44	2
N. N. Palmer & Son	Brodhead	Golds Flossie	6	165	33 5	4.96	1.63	3
H. L. Merrill	Portage	Dear Keepsake	6	159	19.6	9.12	1.74	1
Wm. Shanks	Alloa	Menill	6	364	15.32	6.78	1.04	1
Wm. Shanks	Alloa	Caens Patsy	6	29	18.44	6.18	1.14	1
Wm. Shanks	Alloa	Princess Royal	6	....	24.16	5.21	1.38	1
N. N. Palmer & Son	Brodhead	Miss Madora 2nd	7	46	28.05	5.95	1.67	1
N. N. Palmer & Son	Brodhead	Trix of Lakeside	7	76	24.95	5.37	1.34	1
C. B. Miller & Co	Madison	Maudines Bell	7	250	12.48	5.47	.68	5
H. C. Taylor	Orfordville	Brown Bessy	7	283	28.2	5.35	1.51	1
H. C. Taylor	Orfordville	Brown Bessy	8	184	34.36	5.47	1.88	7
C. B. Miller & Co	Madison	Elmwood Juaniata	8	235	12 95	5.49	.75	5
N. N. Palmer & Son	Brodhead	Badger Girl	9	170	25.15	6.60	1.67	1
H. C. Taylor	Orfordville	Loreta	9	105	39.6	4.70	1.86	1
N. N. Palmer & Son	Brodhead	Sallie Bugler	10	91	26.2	5.46	1.44	1
Victor Lowe	Palmyra	Suamico	12	....	14.1	5.67	.80	1
Geo. C. Bryant	Madison	Baby Ryan	9	95	36.0	4.25	1.53	2

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Table showing average test for one day of individual cows, arranged according to breed and ages of animals.

Owner.	Address.	Name of cow.	Age.	Days in lactation.	Av. milk per day.	Av. fat per day.	Av. fat per day.	No. of days tested.
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Victor Lowe	Palmyra	Koffees Lady Pogis	3	....	20.5	5.17	1.06	2
Victor Lowe	Palmyra	Koffees May Belle	3	....	19.0	5.40	1.03	2
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N. N. Palmer & Son	Brodhead	Fannies Fairy	5	73	31.2	5.35	1.67	3
C. B. Miller & Co	Madison	Callie Logan	3	90	21.6	4.77	.93	2
Victor Lowe	Palmyra	Rubina Love	4	....	19.8	5.15	1.02	2
Victor Lowe	Palmyra	Ouachette 3rd	4	....	28.3	5.79	1.35	1
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C. B. Miller & Co	Madison	Louis Grace	6	37	27.24	4.19	1.14	5
C. B. Miller & Co	Madison	Dame Rhoda	6	50	20.5	6.27	1.29	5
R. S. Kingman	Sparta	Pet Pedro	6	52	31.8	6.13	1.95	2
R. S. Kingman	Sparta	Linda Pedro	6	142	28.6	6.33	1.81	2
R. S. Kingman	Sparta	Linda Pedro	8	85	32.6	6.20	2.02	2
R. S. Kingman	Sparta	Riotera Pogis	6	62	29.9	5.08	1.52	2
R. S. Kingman	Sparta	Pluma Pedro	6	....	25.8	5.58	1.44	2
N. N. Palmer & Son	Brodhead	Golds Flossie	6	165	33.5	4.96	1.63	3
H. L. Merrill	Portage	Dear Keepsake	6	159	19.6	9.12	1.74	1
Wm. Shanks	Alloa	Menill	6	364	15.32	6.78	1.04	1
Wm. Shanks	Alloa	Caens Patsy	6	29	18.44	6.18	1.14	1
Wm. Shanks	Alloa	Princess Royal	6	....	24.16	5.21	1.38	1
N. N. Palmer & Son	Brodhead	Miss Madora 2nd	7	46	28.05	5.95	1.67	1
N. N. Palmer & Son	Brodhead	Trix of Lakeside	7	76	24.95	5.37	1.34	1
C. B. Miller & Co	Madison	Maudines Bell	7	250	12.48	5.47	.68	5
H. C. Taylor	Orfordville	Brown Bessy	7	283	28.2	5.35	1.51	1
H. C. Taylor	Orfordville	Brown Bessy	8	184	34.36	5.47	1.88	7
C. B. Miller & Co	Madison	Elmwood Juaniata	8	235	12.95	5.49	.75	5
N. N. Palmer & Son	Brodhead	Badger Girl	9	170	25.15	6.60	1.67	1
H. C. Taylor	Orfordville	Loreta	9	105	39.6	4.70	1.86	1
N. N. Palmer & Son	Brodhead	Sallie Bugler	10	91	26.2	5.46	1.44	1
Victor Lowe	Palmyra	Suamico	12	....	14.1	5.67	.80	1
Geo. C. Bryant	Madison	Baby Ryan	9	95	36.0	4.25	1.53	2

Table showing average test for one day of individual cows.—Continued.

Owner.	Address.	Name of cow.	Age.	Days in lactation.	Av. milk per day.	Av. fat per day.	Av. fat per day.	No. of days tested.
I—Jerseys.			Ye'rs		Pounds.	Per cent.	Pounds.	
Jas. Morey	Merrimack	Fifers Fairy	7		23.0	6.00	1.38	2
H. C. Adams	Madison	Quachette 2nd.			30.8	5.42	1 67	3
H. C. Adams	Madison	Hedwig L			24.5	4.37	1.07	3
H. C. Adams	Madison	Queer Girl			35.2	4.00	1.41	3
H C Adams	Madison	Astrea 2nd			22.0	4.50	99	3
H. C. Adams	Madison	Margurite Claire			23.8	5.04	1.20	3
H C. Adams	Madison	Lady Lodi			29.1	4.47	1.30	3
H. C Adams	Madison	Maid of Ranney			35.7	4.18	1.49	3
H. C. Adams	Madison	Vidina Labrocq			29.1	4.36	1.27	3
H C. Adams	Madison	Rubinos Faith	H'if'r		21.65	4.48	.97	3
H. C. Adams	Madison	Pride of Evergreen			21.7	4 93	1.07	3
Griffith	Whitewater	Patrina			20 5	4.19	.85	1
Griffith	Whinewater	Chicorica			23.7	3.56	84	1
Average for 54 Jerseys					*23 8*	*5.34*	*1.26*	
II—Holsteins.								
Gillett & Son	Rosendale	Colantha 3d	2	33	40.1	3.34	1.34	1
Gillett & Son	Rosendale	Duchess of Springvalle 4th.	2½	38	33.29	3.09	1.03	6
Gillett & Son	Rosendale	Duchess Clothilda	3	42	53.39	3.40	1.82	3
Rust Bros	N. Greenfield	Altje Salo	2	35	37.3	3.46	1.29	3

Rust Bros	N. Greenfield	Altje Salo	5	156		3.36	1.52	2
Gillett Son&	Rosendale	Aggie Loeman Clothilde	3	124	38.9	3.13	1.22	2
Gillett & Son	Rosendale	Johanna May	4	120	49.0	3.32	1.63	2
Gillett & Son	Rosendale	Johanna 5th	7	41	84.5	2.96	2.50	2
Gillett & Son	Rosendale	Johanna 4th	8	225	43.5	3.61	1.57	2
Rust Bros	N. Greenfield	Schoone	8	30	59.8	3.44	2.06	2
Rust Bros	N. Greenfield	Schoone	9	395	21.8	3.94	.86	2
Rust Bros	N. Greenfield	Schoone	11	3	63.6	3.29	2.09	2
Gillett & Son	Rosendale	Rijanetta	11	37	55.92	2.99	1.65	8
Rust Bros	N. Greenfield	Altje Salo Princess	.....	.....	46.3	3.18	1.47	2
Rust Bros	N. Greenfield	Aggie Beck	.....	35	45.3	3.62	1.64	3
Rust Bros	N. Greenfield	Beimkje	.....	360	22.1	3.98	.88	3
Average for 15 Holsteins	.....	.....	.....	.....	*47.89*	*3.36*	*1.54*	.....
III—Guernsey.								
Chas. L. Hill	Rosendale	Madam Bishop	.....	.....	*24.1*	*6.31*	*1.59*	*1*
IV—Short Horns.								
Kennedy Scott	Rio	Duchess of Lowville	6	119	30.45	3.58	1.09	1
John W. Ganes	Lowell	Sue Cady	8	28	41.9	2.93	1.23	2
A. A. Arnold	Galesville	Donna Maria	9	137	19.2	3.60	.69	2
A. A. Arnold	Galesville	Lady Campbell	12	118	32.00	3.23	1.04	2
A. A. Arnold	Galesville	Lady Campbell	13	.....	28.00	2.57	.72	2
Average for 4 Shorthorns	.....	.....	.....	.....	*31.01*	*3.29*	*1.02*	.....
V—Brown Swiss.								
T. H. Inman	Hanover	Ilda	*7*	*395*	*20.9*	*4.97*	*1.04*	*2*

Table showing average test for one day of individual cows—Continued.

Owner.	Address.	Name of cow.	Age.	Days in lactation.	Av. milk. per day.	Av. fat per day.	Av. fat per day.	No. of days tested.
VI—Red Polls.			Ye'rs		Pounds.	Per cent.	Pounds.	
J. W. Martin	Richland City	Delia	2	54	27.7	3.82	1.06	2
J. W. Martin	Richland City	Hera	7	36	55.5	2.88	1.60	1
J. W. Martin	Richland City	Hemithea	7	106	34.0	3.52	1.20	....
Average for 3 Red Polls	....	....	......	....	*39.1*	*3.41*	*1.29*	....
VII—Grade Jerseys.								
John M. True	Baraboo	Brownie	2	....	19.1	5.31	1.11	1
S. E. Guernon	Waukesha	Nellie	3	302	22.1	5 16	1.14	1
S. E. Guernon	Waukesha	Dollie	3	111	28.5	4.92	1.40	1
S. E. Guernon	Waukesha	Crumple	3	95	33.8	5.83	1.97	1
S. E. Guernon	Waukesha	Vic	4	183	22.4	6.24	1.40	1
S. E. Guernon	Waukesha	Polly	5	243	17.6	5.97	1.02	1
S. E. Guernon	Waukesha	Speckle	6	185	28.1	4.70	1.32	1
R. S. Kingman	Sparta	Daisy	6	122	40.65	5.95	2.42	2
John M. True	Baraboo	Daisy	6	145	41.13	5.98	2.46	1
John M. True	Baraboo	Daisy	6	150	41.71	4.73	1.97	7
S. E. Guernon	Waukesha	Bertha	7	178	31.2	4 23	1.32	1
S. E. Guernon	Waukesha	Tricky	7	122	24.1	4.90	1 18	1
S. E. Guernon	Waukesha	Rab	10	121	30.1	4.75	1.43	1
S. E. Guernon	Waukesha	Brownie	12	313	18.4	4.73	.87	1

S. E. Guernon.	Waukesha	Enos	12	172	24.0	5.09	1.22	1
R. S. Kingman	Sparta	Smithy	...	...	34.9	4.38	1.53	2
Average for 15 grade Jerseys	...	...	...	...	*27.21*	*5.00*	*1.36*	...
VIII—Natives.								
S. E. Guernon	Waukesha	Jennie	3	264	24.6	3.41	.84	1
S. F. Guernon	Waukesha	Ida	16	129	26.7	3.20	.86	1
Average for 2 Natives.	...	...	...	...	*25.7*	*3.30*	*.85*	...

In most cases the cows tested have been selected to compete for prizes so that the results in no sense represent what the average cow would do, nor do they show the relation between the different breeds.

The Influence of Age upon Quality of Milk.

Although a question of this kind cannot be definitely settled without examining the milk of a large number of cows through several periods of lactation we should expect, if much change occurred, that a noticeable difference in the per cent. of fat would be found between the older and younger cows of each breed; this, however, is not the case and the inference is that the difference between different ages is very small, if, indeed, there is any at all. In some cases where the same cow has been tested at different ages there is found a considerable difference in the per cent. of fat in the milk, but the richer milk is sometimes found in the first and sometimes in the second test. If in such cases the influence of advancing lactation in improving the quality of milk is considered, most of the difference will disappear. This is illustrated in the tests of the Jerseys, Fannie's Fairy and Linda Pedro, also in the tests of the Holstein's Schoone and Altje Salo. The cows that have exceeded four years of age have yielded considerably more butter fat per day than those younger, but this in almost every case is due to an increase in yield of milk rather than to change in the per cent. of fat. The cows over four years of age show very little difference in yield that can be attributed to age, and it is probable that cows that have reached maturity will continue for several years to do about the same each year.

In some cases where the tests continued several days there was found little variation either in the yield or quality of the milk from day to day; in others the variation from milking to milking is quite remarkable. As an illustration of this variation the test of Maudine's Belle is given in detail in the following table:

TABLE 2.—*Test of Maudine's Belle Showing Daily Variations.*

	Time.	Milk.	Fat.	Fat.	Total for 24 Hours.		
					Milk.	Av. fat for day.	Fat.
		Pounds.	Per cent.	Pounds.	Pounds.	Per cent.	Pounds.
1st day	A. M.	5.0	5.15	.26	9.50	4.21	.40
	P M.	4.5	3.20	.14			
2d day	A. M.	8 75	9.00	.79	12.75	7.30	.93
	P. M.	4.00	3.40	.14			
3d day	A. M.	8.25	4.80	.40	14.50	5.45	.79
	P. M.	6.25	6.30	.39			
4th day	A. M.	6.40	4.10	.26	12.65	4.74	.60
	P. M.	6.25	5.41	.34			
5th day	A. M.	7.50	6.00	.45	13.00	5.07	.66
	P. M	5.50	3.90	.21			

It will be noticed that during the second day she gave 2¼ times as much fat as upon the first day, although the quantity of milk was increased only one-third. The greatest difference between any two milkings was found on the evening of the first day and the next morning, where the difference amounted to 5.8 per cent. fat. It is not usual for cows to vary as much as this, but such cases occur, especially where cows are disturbed or excited in any way.

There were eight cows in the herd to which this cow belonged and they were tested for five days; this gave 40 comparisons between the evening's and morning's milk, the intervals between the milkings being the same. In these cases the morning's milk was richer than the evening's milk seventeen times and twenty-one times the night's milk was the richer; in the two other cases the milk tested the same in the morning and evening. As a rule, where the interval between milkings vary the longer the interval the poorer is the milk.

TESTS AT HOME AND AT FAIRS.

There is a general impression that cows tested at fairs do not do as well as when tested at home, but very few careful observations have been made to test this point. The following tests bear directly upon the question.

First, the herd of C. B. Miller & Co. of Madison, consisting of eight cows, was tested at the Dane county fair in 1890. The cows were only three miles from home and had not been jolted around on cars so that they had been disturbed much less than is usually the case with cows on exhibition. The test at the fair lasted four days; after a week's rest they were tested again at home for five days; the results of the two tests are given in the following table:

TABLE 3.—*Test of C. B. Miller & Co.'s herd at home compared with the test at the Dane county fair.*

NAME OF COW.	AVERAGE TEST PER DAY AT HOME.			AVERAGE TEST PER DAY AT FAIR.		
	Average Lbs. milk per day.	Average per cent. fat.	Average Lbs. fat per day.	Average Lbs. milk per day.	Average per cent. fat.	Average Lbs. fat per day.
Ida Pogis	9.35	5.62	.526	8.5	4.65	.395
Maudine's Belle	12.48	5.47	.676	14.8	5.37	.795
Callie Logan	13.45	6.17	.826	12.0	6.58	.790
Louis Grace	23.24	4.19	1.138	24.3	3.84	*.933
Dame Rhoda	20.50	6.27	1.29	21.0	5.47	1.148
Elmwood Juanita	12.95	5.49	.75	16.75	4.59	.768
Neata Bullard	12.95	6.87	.894	11.1	6.57	.730
Annie Johnson	14.55	6.05	.878	13.8	5.35	.738
Average of herd for one day	*14.92*	*5.84*	*.872*	*15.28*	*5.15*	*.787*

*Average of three days, the other tests are averages of four days.

It will be noticed that the weight of milk per cow is practically the same at the fair as at home, the test at the fair averaged .69 per cent of fat less than the test at home. The average yield of fat per cow for 24 hours was .787 lbs. at the fair and .872 lbs. at home. Maudine's Belle and Elmwood

Juanita did better at the fair than at home, while the others did better at home than at the fair.

The second experiment was with two Holstein cows, Rijanetta and Duchess of Springvale 4th from the herd of Gillett & Son of Rosendale. They were first tested for two days at home and the next week they were taken on the cars to the Fond du Lac fair, where they were tested for three days; on the following week they were taken to the State fair at Milwaukee, where they were again tested. The following table gives the details of the test, and it will be seen that there was practically no difference either at home or at the fair. The slight difference shown by Duchess of Springvale 4th was in favor of the fair.

TABLE 4.—*Test of Rijanetta at Home and at Fair.*

	Hour milked.	FIRST DAY.			SECOND DAY.			THIRD DAY.		
		Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
		Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.
At home.	12.30 P. M...	18.44	2.75	.51	18.31	3.35	.61	......	......	......
	S. P. M....	16.94	2.40	.41	17.75	2.75	.49	......	......	......
	5.30 P. M...	25.00	2.40	.60	24.06	2.50	.60	......	......	......
	Total for 24 hours.....	***60.38***	***2.52***	***1.52***	***59.94***	***2.83***	***1.70***	......	......	......
At Fond du Lac County Fair.	8.30 P. M...	19.25	2.80	.54	16.60	3.00	.50	16.00	2.70	.43
	5.30 A. M...	19.50	2.20	.43	20.00	2.30	.46	20.70	2.10	.43
	12.30 P. M..	18.50	3.20	.59	17.20	4.10	.71	17.50	3.20	.56
	Total for 24 hours.....	***57.25***	***2.73***	***1.56***	***53.80***	***3.10***	***1.67***	***54.20***	***2.61***	***1.42***
At Wisconsin State Fair.	5.30 P. M...	24.40	2.90	.71	20.50	2.40	.49	22.60	3.30	.75
	12.30 P. M..	14.60	4.00	.58	16.90	4.05	.68	13.40	3.30	.44
	8. P. M....	17.30	2.90	.50	15.60	3.20	.50	16.50	3.90	.64
	Total for 24 hours.....	***56.30***	***3.18***	***1.79***	***53.00***	***3.15***	***1.67***	***25.50***	***3.49***	***1.83***

Duchess of Springvale 4th at home and at fairs.

At home.	12.30 P. M..	10.25	3.30	.34	10.19	3.20	.33	......	.....	......
	8. P. M. ...	9.63	2.85	.28	9.18	3.20	.29	......	......	......
	5.30 A. M ..	14.75	2.30	.34	13.69	2.45	.34	....	......	......
	Total for 24 hours.....	***34.63***	***2.75***	***.96***	***33.01***	***2.99***	***.96***	....	......	......
At Fond du Lac County Fair.	8. P. M.....	10.20	3.00	.31	10.40	3.40	.35	10.40	3.15	.33
	5.30 A. M...	12.40	2.70	.33	12.00	2.20	.26	11.60	2.40	.28
	12.30 P. M..	10.40	3.80	.40	11.20	4.60	.52	10.50	3.60	.38
	Total for 24 hours.....	***33.00***	***3.16***	***1.04***	***33.60***	***3.33***	***1.13***	***32.50***	***3.04***	***.99***
At Wisconsin State Fair.	5.30 A. M ..	12.20	3.10	.38	......	.....	.....	....	......	......
	12.30 P. M ..	10.60	3.70	.39	......	.....	......	....	......	......
	8. P. M	10.20	3.30	.34	......	......	......	....	......	......
	Total for 24 hours.....	***33.00***	***3.37***	***1.11***	......	......	.....	....	......	......

The week after the above tests were made these cows were taken to the Indiana state fair, and the week following to the Illinois state fair at Peoria; at the latter place they were tested by Professor Farrington. The following table shows the result of his test. It will be seen that there had been a great falling off both in yield of milk and in the per cent. of fat, probably due to the fatigue and excitement of the journey.

TABLE V.—*Gillett's Holsteins at Illinois State Fair*, 1891.

TIME MILKED.	RIJANETTA.			DUCHESS OF SPRINGVALE 4TH.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
	Lbs.	Per cent.	Lbs.	Lbs.	Per cent.	Lbs.
Morning....................	20.5	1.7	.35	15	1.0	.15
Noon	9.0	2.2	.20	6	....	....
Night......................	9.5	1.8	.17	5	1.3	.07
Total	***39.0***	***1.84***	***.72***	***26***	....	....

In several instances where cows have been tested at home and at thefairs they have shown the milk to be much richer at the fair than when at home. For instance, the Jersey cow Dear Keepsake, tested at the Portage fair in September, 1890, gave 11 pounds of milk that tested 10.7 per cent. of fat, the next milking she gave only 8.06 pounds of milk which tested 7 per cent. of fat.

At the Baraboo fair the grade Jersey, Daisy, owned by Hon. J. M. True, gave a high test. Mr. True's place adjoined the fair grounds and the cow was kept in her usual quarters at night but on the fair grounds during the day. The details of this test are given in table six.

TABLE VI.—*Test of Mr. True's Cow, Daisy, at Baraboo Fair.*

	Lbs. milk.	Per cent. fat.	Lbs. fat.
6 p. m.	21.75	6.5	1.41
6 a. m.	19.38	5.4	1.05
Total for day	*41.13*	....	*2 46*

It will be noticed that the highest per cent. of fat was in the evening after the excitement of the day on the fair grounds, while the lower percentage followed the quiet night condition. The interval between milkiugs were equal. The next week the cow was tested for seven days at home, the details of which are given in table seven.

TAALE VII.—*Test of Hon. J. M. True's Cow, Daisy, at Home.*

Date.	Hour.	Lbs. milk.	Per cent. fat.	Lbs. fat.	For Twenty-four Hours.	
					Lbs. milk.	Lbs. fat.
Sept. 29	6 a. m.	17.5	4.70	.82	....	....
	6 p. m.	21.0	4.70	.99	38.50	1.81
Sept. 30	6 a. m.	21.25	5.03	1.07	40.25	....
	6 p. m.	19.00	3.99	.76	....	1.83
Oct. 1	6 a. m.	21.25	5.16	1.10	....	....
	6 p. m.	19.25	4.46	.88	40.50	1.98
Oct. 2	6 a. m.	22.50	5.16	1.16	....	....
	6 p. m.	19 00	4.46	.85	41.50	2 01
Oct. 3	6 a. m.	22.75	4.93	1.12	....	....
	6 p. m.	21.00	4.93	1 07	44.50	2.19
Oct. 4	6 a. m.	21.00	4.57	.96	....	....
	6 p. m.	21.75	4.69	1.02	42.75	1.98
Oct. 5	6 a. m.	21.75	4.69	1.02	....	....
	6 p. m.	22 25	4.46	.99	44.00	2 01
Totals and av.	....	*292.00*	....	*13.81*	*41.71*	*1.97*

It will be noticed that at no time during the home test did her milk contain as high a per cent. of fat as at the fair, although the quantity of milk was about the same in both cases. The yield of fat during the week's test at home was 13.81 pounds; if she had given milk which averaged as rich as her test at the fair showed, she would have yielded 17.22 pounds of fat during the week.

In order to obtain a photograph of this cow with her udder distended, she was turned out of the barn on the morning after the test was completed without being milked; usually she had been milked at 6 o'clock. The cow seemed much worried over this irregular treatment, and after she was let out of the barn she was considerably excited over being separated from the other animals in order that the photograph might be taken. It was after 9 o'clock when she was driven into the barn and milked; she gave 28.25 pounds of milk at this milking, which tested 6.33 per cent. fat; this was more than 1 per cent. higher than any test

which she had made during the week, and nearly as high as her test at the fair. It is probable that the excitement caused by the fair and by the irregular treatment when the photograph was taken caused these high tests.

The value of a cow depends largely upon her being a persistent milker. Some cows yield a large quantity of butter fat for a short time and then rapidly fall off and perhaps remain dry for some months so they will scarcely pay for their keeping the whole year.

Several instances of cows yielding large quantities of fat at advanced periods of lactation will be found in Table I. The most notable is that of Brown Bessie with a yield of 1.51 pounds of fat after being milked 288 days. On this test she was selected for competition in the World's Fair dairy test where she won the sweepstake prize. During this test on her one hundred and eighty ninth day in milk she gave 2.44 pounds of fat.

CONCLUSIONS.

First. The quality of milk improves but little, if at all, as the cows grow older.

Second. The same cow may show great variations in the quantity and quality of her milk from day to day.

Third. There is not usually as much difference between tests at fairs and at home as is claimed, but cows may be become so fatigued that they will not do nearly their normal work.

Fourth. Excitement may increase the fat in milk as well as diminish it.

Fifth. Individuality is a great factor in determining a cow's value.

Sixth. No one breed can claim all the good cows.

THE EFFECT OF SALT UPON CHEESE.

J. W. DECKER.

The following experiments were undertaken to determine the effect of salt upon the texture and quality of cheese. In the first experiment 31.5 lbs. of curd was divided into three equal portions; to No. 1 no salt was added, while Nos. 2 and 3 were salted at the rate of 1.5 lbs. and 3 lbs. of salt per 100 lbs. of curd, respectively. The weight of green cheese from each of these lots was: No. 1, 10 lbs.; No. 2, 9.75 lbs., and No. 3, 9.5 lbs. The analyses which follow show that this difference is due to a more thorough expulsion of moisture from the salted curds. When four weeks old these cheese were cut and samples examined. At this time No. 1, containing no salt, was bulged at the ends and contained numerous gas reservoirs. It had a sweetish taste and a pasty texture; No. 2 was slightly bulged at the ends and contained but few holes which were smaller than those in No. 1. It also had a much better flavor and texture than No. 1, but was a little too weak bodied. No. 3 was a very fine, slow curing cheese; it was not bulged at all and contained no holes; its flavor and texture were perfect, although it was not as far advanced as the others. The upper row in the accompanying illustration (Fig. 24) shows the appearance of a section through the middle of these cheese when cut.

FIG. 24.—Effect of salt on texture of cheese. No. 1, no salt; No. 2, 1½ lbs. of salt (upper cheese), 2 lbs. (lower cheese) per 100 lbs. of curd; No. 3, 3 lbs of salt per 100 lbs. of curd.

At this time partial analyses were made of these cheese with the results given in the following table:

TABLE I.—*Showing effect of salt upon composition of cheese.*

	Wt. of curd.	Amt. of salt per 100 lbs. curd.	Wt. of green cheese.	Wt. of cheese when analyzed.	Water.	Ash.	Salt.	Ash not salt.
	lbs.		lbs.	lbs.	pr. ct.	pr.ct.	pr.ct.	pr.ct.
Cheese No. 1.......	10.5	.0	10.0	9.4	34.12	2.38	.05	2.33
Cheese No. 2.......	10 5	1.5	9.75	9.2	31.35	3.15	.65	2.50
Cheese No. 3........	10.5	3.0	9.50	8.9	29.82	3.85	1.17	2.68

The analyses show that the cheese from the salted curds contained less moisture than that from the unsalted, the difference being sufficient to account for the difference in yield. They also show that the cheese contained practically no salt except what was added, the salt originally in the milk being mostly lost in the whey. The salt retained by the cheese is not proportional to the amount added to the curd.

Another experiment made in the same way, except that No. 2 was salted at the rate of 2 lbs. instead of 1.5 lbs. per 100 lbs. of curd gave practically the same results. The ap-

pearance of the second lot of cheese is shown in the lower row of the illustration.

Determinations of the ash and salt in the second lot of cheese and in the milk from which they were made are given in the following table:

Table II.—Showing ash and salt in milk and cheese.

	Ash	Salt.	Ash not salt
	Per ct.	Per ct.	Per ct.
Milk used in experiment	.74	.14	.60
Whey from above milk	.62	.17	.45
Cheese No. 1, no salt used	2.34	trace	2.34
Cheese No. 2, salted at the rate of 2 lbs. per 1,000 lbs milk	3.45	.98	2.47
Cheese No. 3, salted at the rate of 3 lbs. salt per 1,000 lbs. milk	3.60	1.03	2 57

It will be seen that aside from the salt the per cent. of ash in the cheese is nearly constant and coincides closely with that found in the first experiment.

At my suggestion Mr. U. S. Baer, a former student in this school, conducted experiments by dividing curds and salting them at rates from 2.25 to 3 lbs. per 100 lbs. of curd. In every case the judgment of the buyer was that the last lot was best, both in texture and flavor.

As a result of our experiments we conclude:

1. Only a trace of the salt originally in the milk is retained by the cheese.

2. Salt applied to curd diminishes the yield of cheese by expelling moisture.

3. Increasing the amount of salt makes the cheese cure more slowly, and up to about 3 lbs. of salt per 100 lbs. of curd cheese of better texture and flavor are obtained.

THE FAT GLOBULES IN COWS' MILK.

F. W. WOLL.

Through the courtesy of the committee in charge of the dairy tests at the World's Columbian Exposition in Chicago during the summer of 1893, the writer had the privilege of making microscopic examination of the milk from the herds competing in the tests, as well as that from individual cows. The work was done in the interval between August 26th, and October 18th, 1893. The results of the examination are given below; the data were obtained from the official samples, taken by the committee or their authorized respresentatives. Samples of the mixed evening and morning milk of the herd milks were examined daily for four consecutive days; composite samples for four day periods were examined in case of the milk from single cows. In the latter case 50 cc. of milk was measured out from the mixed evening and morning sample on four consecutive days, into a pint fruit jar, containing a little potassiun bichromate, and the number of globules was determined in the composite sample. Comparative examinations showed that the results obtained by the two methods agreed within the limits of the error of determination.

The percentages of fat in the examples examined were obtained from the chemist in charge of the analytical work connected with the tests, Prof. E. H. Farrington, and were the official data.

The animals in the tests were all thoroughbred, registered cattle, selected especially for these competitive trials from herds in all parts of the United States, or Canada, and were thus thoroughly representative of the respective breeds. The results of the test will bear out the statement that most of the cows were excellent animals, and that the

herds as a whole were a gathering of dairy cows as has perhaps never before been seen anywhere.

In the following tables the more important data in connection with the special subject under discussion are given.

Examinations of the herd milk were made in the second (the ninety day) breed test, while in the subsequent tests both the mixed herd milk and the milk from the individual cows in the test were examined. The data will be discussed after all the tests have been given.

BREED TEST NO. 2.—(Ninety day butter test.)

From June 1st, to August 29th; seventy-four cows in the test, twenty-five each of the Jersey and Guernsey breeds, and twenty-four of the Short Horn breed. The microscopic examinations of the samples of the herd milk were made during the last four days of the test. The yield of milk, per cent. and yield of fat, average number of globules and their relative size were as given in the following table:

Breed test No. 2.—Aug. 26–29, inclusive.

Breed.	Date.	Av. No. of days from calving	Av. age of cows.	Milk yield.	Fat.	Yield of fat.	No. of globules in .0001 cmm.	Relative size of globules.
			years.	lbs.	per ct.	lbs.		
Jerseys	Aug. 26	....	.....	772.2	4.8	36.67	149	322
	Aug. 27	....	....	740.4	4.5	33.61	158	286
	Aug. 28	....	....	721.1	4.7	35.60	169	290
	Aug. 29	....	....	690.3	5 0	34.62	189	265
Average	....	156	7.6	731.0	4.81	35.12	166	290
Guernseys	Aug. 26	....	....	608.9	4.4	26.11	168	261
	Aug. 27	....	....	597.1	4.1	24.65	177	232
	Aug. 28	....	....	583.8	4.1	24.36	204	201
	Aug. 29	....	....	582.1	4.5	25 45	212	213
Average	....	151	6 8	598.0	4.15	25 14	190	217
ShortHorns	Aug. 26	....	....	660.8	3.5	23.13	....	....
	Aug. 27	....	....	667.2	3.3	22.22	180	183
	Aug 28	....	....	663.1	3.4	22.72	195	174
	Aug. 29	....	....	658.1	3 5	23.23	207	169
Average	....	150	8.0	662.8	3 43	22.72	194	177

BREED TEST No. 3. (Thirty day butter test.)

From August 29th to September 28th; forty-five cows were included in the test, fifteen of each of the herds competing in the preceding test. The cows in this test were selected from those included in test No. 2, with the exception of three Jerseys, five Guernseys and four Short Horns which had not been in any of the previous tests. Samples of the mixed herd milk from each herd were examined microscopically during the first four and last four days of the test; the milk from the individual cows was examined in the same manner as the test progressed. The examination of the milk gave the results given below:

Breed test No. 3.—Aug. 30–Sept. 2, and Sept. 25–28.

Breed.	Date.	Av. No. of days from calving	Milk yield.	Fat.	Yield of fat.	No. of globules in .0001 cmm.	Relative size of globules.
			lbs.	per ct.	lbs.		
Jerseys	Aug. 30		474 3	4.9	22.53	137	358
	Aug. 31		487.2	4.6	22.56	150	307
	Sept. 1		487.8	4.7	22.87	134	352
	Sept. 2		492.9	4.9	23.91	129	383
Average		139	485.6	4 73	22.97	138	343
Jerseys	Sept. 25		432.1	4 8	20.58	154	312
	Sept. 26		448.6	5.4	23.80	155	349
	Sept. 27		451.7	5.2	22.87	140	372
	Sept. 28		458.7	5.0	22.43	155	323
Average		165	447.8	4.98	22.29	151	330
Guernseys	Aug. 30		445.7	4.3	18.83	157	273
	Aug. 31		452.9	4.2	19.14	151	278
	Sept. 1		461.4	4.3	20.04	161	267
	Sept. 2		468.7	4.4	20.25	145	303
Average		107	457.2	4.28	19.57	154	278
Guernseys	Sept. 25		436.6	4.6	19.45	174	265
	Sept. 26		435.1	4.6	19.48	157	292
	Sept. 27		444.0	4.6	19.91	198	233
	Sept. 28		459.5	4.6	20.78	172	267
Average		133	444.3	4.48	19.91	175	256

Breed test No. 3.—*Aug.* 30–*Sept.* 2, *and Sept.*25–28.—Continued.

Breed.	Date.	Av. No. of days from calving	Milk yield.	Fat.	Yield fat.	No. of globules in .0001 cmm.	Relative size of globules.
			lbs.	Per ct.	lbs.		
Short Horns	Aug. 30	....	528.6	3.3	17.89	166	199
	Aug. 31	....	531.2	3.3	17.48	134	246
	Sept. 1	....	539.6	3.3	18.01	150	220
	Sept. 2	....	543.1	3.5	18.79	162	216
Average	....	119	535.6	3.37	18.04	153	216
Short Horns	Sept. 25	....	513.1	3.6	18.75	190	189
	Sept. 26	. . ....	515.5	3.8	18.85	190	200
	Sept. 27	.... ..	514.3	3.5	18.10	156	225
	Sept. 28	. .. ...	523.2	3 5	18.24	149	235
Average	....	145	516.5	3.58	18.49	171	209

Average of both determinations.

	Av. No. of days from calving	Av. age of cows.	Milk yield.	Fat.	Yield of fat.	Globules in .0001 cmm.	Relative size of globules.
		Years.	Lbs.	Per ct.	Lbs.		
Jerseys	142	7.7	466.7	4.85	22.63	144	337
Guernseys	121	7.1	450.7	4.38	19.74	164	267
Short Horns	132	8.4	526.1	3.47	18.26	162	214

Examination of milk from individual cows on breed test No. 3.

No.	Name of cow.	Age yrs.	Da'e of last calving	Date of examination.	Days from calving.	Av. milk yield.	Fat.	No. of globules in .0001 cmm.	Rel. size of globules.
	Jersey Cows.		1893.	1893.		lbs.	per cent.		
1	Ida Marigold, 32615.......	8.2	Apr. 29	Sept. 4–7	130	34.6	4.95	135	366
2	Islip Lenox, 31703	10.	May 17	Sept. 4-7	112	26.0	5.53	117	473
3	Brown Bessie, 74997......	8.5	Apr. 21	Sept. 4–7	138	40.6	5.23	156	336
4	Sayda Third, 17317.. ..	11.5	Mar. 13	Aug. 30–Sept. 2	172	28.0	4.43	138	325
5	Baroness Argyle, 40498...	7.	Apr 21	Sept. 8–11	142	29.6	4.93	148	333
6	Flora Temple, 40086	7.3	Apr. 1	Aug. 30–Sept. 2	153	31.1	4.75	137	346
7	Signal Queen, 30869.......	10.	Apr. 4	Sept. 8–11	159	31.0	4.25	180	236
8	Sheba Rex, 47429.........	8.	Feb. 22	Sept. 8–11	200	33.8	4.50	126	333
9	Exile's Lulu, 49984	7.	Apr. 15	Sept. 12–15	152	32 2	4.55	155	294
10	Merry Maiden, 64949......	5.	Apr. 15	Sept. 12–15	152	33.8	5.50	92	598
11	Cupid's Jersey Maid, 35040	8.	May 1	Sept. 12–15	136	35.7	4.33	192	225
12	Stoke Pogis Regina, 48301	8.1	July 29	Sept. 16-19	51	34.1	4.93	131	377
13	Katherine of Pittsford. 73169....	4.3	Aug. 10	Sept. 16–19	39	35.0	4.13	162	255
14	Hugo Comtess, 68894.....	6.	Mar. 7	Sept. 16–19	195	16.8	7.58	158	482
15	Romp's Princess, 51185...	6.3	Apr. 17	Sept. 20–23	154	26.4	5.85	123	475
	Guernsey Cows.		1893.	1893.					
1	Amanda, 2553............	8.	May 10	Sept. 4–7	119	29.0	4.03	178	226
2	Aldine, 1211....	10.5	Apr. 16	Sept. 4–7	143	26.4	4.65	129	359
3	Careno...................	3.5	July 28	Sept. 4–7	140	30.2	4.88	93	525
4	Duchess of Orleans.......	...	July 1	Sept. 8–11	71	36.9	3.60	135	266
5	Essence imp., 3667.......	8.	May 17	Sept. 8–11	116	21 2	5.00	206	243
6	Ethics of Cornwall.......	5.	Apr. 6	Sept. 8–11	157	30.8	4.50	176	256
7	Lady of Ellerslie, 4543...	4.3	May 9	Sept. 12–15	128	22.3	5.20	220	236
8	Marita........	8.0	July 10	Sept. 12–15	66	33.4	3.35	99	337
9	Materna, 1334.	11.	Apr. 5	Aug. 30–Sept. 2	149	36.6	3 93	208	189
10	Purity....................	8.5	Aug. 12	Sept. 12–15	33	35.1	4.33	105	413
11	Princess Aster, imp., 4439	5.5	May 13	Sept. 16–19	128	28.4	3.88	174	223
12	Rosetta Fifth, 3696.......	8 5	Mar. 27	Sept. 16–19	175	29.6	4.28	280	153
13	Select Eighth, 4059	6.	Mar. 16	Sept. 16–19	186	28.0	5.10	174	293
14	Sweet Ada, 3596..........	8.2	Mar. 20	Aug. 30–Sept. 2	154	32 7	4.50	190	237
15	Vesta's Valencia..	4.5	June 22	Sept. 20–22	92	33.2	4 33	156	277

Examination of milk from individual cows on test No. 3.

No.	Name of cow.	Age yrs.	Date of last calving	Date of examination.	Days from calving.	Av. milk yield.	Fat	No. of globules in .0001 cmm.	Rel. size of globules.
	Short Horn Cows.		1893.	1893		lbs.	per cent.		
1	Kitty Clay Fourth *29*, 553.	9.5	July 19	Sept. 4-7	49	56.3	3.23	188	172
2	Kitty Clay Third *29*, 553	10.5	Apr. 24	Sept. 4-7	135	43.2	3.23	39	836
2	Kitty Clay Third *29*, 553			Sept. 20-23	151	39.8	3.38	49	692
3	Vervain, *34*, 825.	8.5	Aug. 5	Sept. 4-7	32	39.2	3.38	114	283
4	Waterloo Daisy, 19355....	5.	Apr. 21	Sept. 8-11	142	41.0	3.43	226	152
5	Fair Maid of Hulb't, 9047	10.3	May 25	Aug. 30-Sept. 2	99	31.6	3.43	96	359
6	Kitty Clay Fifth, *37*, 872	6.3	July 5	Sept. 8-11	67	29.5	4.13	38	1,095
6	Kitty Clay Fifth, *37*, 872			Sept. 20-23	79	32.3	3.80	38	1,000
7	Kitty Clay Seventh, *38*, 671	6.5	Apr. 10	Sept. 8-11	153	27.1	4.28	135	316
8	Lucy Ann, *35*, 925.	8.3	Apr. 27	Sept. 12-15	140	26.0	3.80	263	144
9	Betsey Seventh.	7.5	Apr. 8	Sept. 12-15	159	31.1	3.70	120	309
10	Belle Price, *26*, 604	10.2	Mar. 3	Sept. 12-15	197	38.1	4.20	280	150
11	Lady Bright, *3*, 884	16.4	June 14	Sept. 16-19	96	35.3	3.58	38	942
12	Rosa, *36*, 714.............	5.2	Mar. 27	Sept. 16-19	175	29.5	3.48	284	122
13	Nora	7.2	Apr. 13	Aug. 30-Sept. 2	141	38.5	3.58	57	627
13	Nora			Sept. 20-23	162	34.0	3.78	54	696
14	Genevieve, *36*, 860	9	Apr. 4	Sept. 16-19	167	34.0	3.43	353	97
15	Bashful Second, *35*, 380.	7.3	Mar. 17	Sept. 20-23	189	30.5	4.25	38	1,127
15	Bashful Second, *35*, 380.			Sept. 25-28	194	32.8	4.18	40	1,056

BREED TEST NO. 4. (HEIFER TEST.)

From September 30th to October 20th, inclusive; seven Jersey heifers and six Short Horn heifers were included in the test. The samples of milk from the two herds as well as from the individual cows in the test were examined during the first four days of the test.

Breed Test No. 4, October 1-4, 1893.

Breed.	Date.	Av. No. days from calving.	Av. age of cows.	Milk yield.	Fat.	Yield of fat.	No. of globules in .0001 cmm.	Relative size of globules.
		days.	years.	lbs.	pr.ct.	lbs.		
Jersey (7 cows).....	Oct. 1...	....	... .	156.0	4.9	7.79	135	362
	Oct. 2...	.. ....	....	156.4	4.8	7.51	150	320
	Oct. 3...	....	....	156.3	4.8	7.50	161	298
	Oct. 4...	....	....	154 9	4.8	7.42	178	269
Average.....		66	2.4	156.7	4.82	7.56	156	309
Short Horn (6 cows)	Oct. 1...	....	....	124.8	4.1	5.10	71	579
	Oct. 2...	....	....	127.3	4.0	5.09	87	462
	Oct. 3...	....	....	124.0	4.0	4.96	77	518
	Oct. 4...	....	....	124.0	4 0	4 96	84	478
Average.....		107	2 9	124.9	4.03	5.03	80	504

Examination of milk for individual cows.

No.	Name of cow.	Age.	Date of last calving.	Date of examination.	Days from calving.	Average milk yield.	Fat.	No. of globules in .0001 cmm.	Relative size of globules.
	Jersey cows.	years	1893	1893.			pr. ct.		
1	Elturia, 80701......	3	July 15	Oct. 1-4	80	20.6	4.40	155	238
2	Campania, 83475....	3	July 27	Oct. 1-4	68	24.8	4.28	187	229
3	Lily Garfield, 79819.	2	July 12	Oct. 1-4	83	26.9	5.03	143	353
4	Iola F., 85529	2	July 13	Oct. 1-4	82	22 6	4.63	148	313
5	Woodstock Mystery 77746..	2	Aug. 23	Oct. 1-4	41	18.3	5.55	105	529
6	Woodstock Lady, 80619.....	2	Aug. 15	Oct. 1-4	49	20.1	4.40	124	354
7	Jeanette of Pittsford, 73185	3	Aug. 4	Oct. 1-4	60	23.5	4.35	125	348
	Short Horn cows.								
1	Kitty Clay 8th......	2½	April 5	Oct. 1-4	181	14.8	4.56	56	813
2	Aggie 2nd	3	July 1	Oct. 1-4	94	23.1	4.00	47	853
3	Miss Rennick 24th..	3	Sept. 18	Oct. 1-4	15	23 4	3.83	19	1,982
3	Miss Rennick 24th .	3	Sept. 18	Oct. 15-18	29	27.2	3.27	24	1,413
4	Fancy 15th..... ...	3	Sept. 15	Oct. 1-4	18	24.8	3.77	65	574
5	Blossom	3	April 17	Oct. 1-4	169	16.9	3 63	208	175
6	Belle of Trowbridge	3	April 27	Oct. 1-4	159	17.4	4 50	117	385

DISCUSSION OF RESULTS.

The data given in the preceding tables were obtained from 99 cows in all, and those of single determination from 58 cows. The average determinations of the milk from the different herds have been calculated, and were as follows:

SUMMARY OF RESULTS.

Breed test No. 2; *examinations made Aug.* 26–29, *inclusive.*

Breed.	No. of cows	Av. No. of days from calving.	No. of globules in .C001 cmm.	Relative size.	Av. diameter of globules.
					mm
Jersey	25	156	166	290	.00395
Guernsey	25	151	190	217	.00358
Short Horn	24	150	194	177	.00335
Average	....	*152*	*183*	*228*	*.00363*
Breed test No. 3; *examinations made Aug.* 30,–*Sept.* 2, *and Sept.* 25-28.					
Jersey	15	142	144	337	.00415
Guernsey	15	121	164	267	.00384
Short Horn	15	132	162	214	.C0357
Average	....	*132*	*157*	*273*	*.00385*
Breed test No. 4; *examinations made Oct.* 1–4, *inclusive.*					
Jersey	7	66	156	309	.00403
Short Horn	6	107	80	504	.00479
Average	....	*87*	*118*	*407*	*.00441*
Average for all breeds and tests	....	*128*	*157*	*289*	*.00391*

Twelve new cows were included in the test No. 3, and the number on the test decreased to 15 cows from each herd. In tests No. 2 and 3 the average size of the globules in the milk from the different herds was largest with the Jerseys, the Guernseys coming next and the Short Horns last. In the heifer test, on the other hand, the Short Horns had the larger average globules, in spite of the fact

that they were 41 days further advanced in the period of lactation than the Jersey heifers, which as has been previously shown, would naturally bring a diminution in the size of the globules.[1] The average results for all herds and tests were 157 globules in .0001 cmm. and a relative size of 289, corresponding to an average diameter of .00391 mm., the results having been obtained with cows 128 days in milk.

An examination of the results obtained with the samples of milk from individual cows show nothing of particular interest except in the case of the Short Horn cows and heifers Kitty Clay 3rd and 5th, Nora Bashful 2nd and Miss Rennick, all of which had a remarkably low number of globules per cubic millimeter of milk and therefore also a high relative size of the globules. The explanation naturally suggesting itself was that the cows were feverish when the examinations were made,[2] but I am informed by the Superintendent of the Short Horn herd, Col. H. H. Hinds, that the cows were perfectly normal at the time, and gave no indication of being sick, either from the amount of food eaten, milk flow or per cent. of fat in the milk. We must therefore conclude that individual cows may occasionally give on an average only 19 globules per cubic millimeter of milk at the beginning of their lactation periods, the average relative size of the globules being 1982 (= diameter of average sized globules .00749 millimeter).

The plan of examination followed in the investigation under discussion makes possible a check of the results obtained in the examination of herd milks and in that from individual cows. If we calculate the average data of the determinations of the globules in the milk for the individual cows considering the quality of milk produced by each animal in each case, we have the following statement:

[1] Wis. Experiment Sta. Report, VII, 240; Agricultural Science, VI, 445-453.

[2] Wis. Expt. Sta. Report, VII, 246; Agricultural Science, VI, 522.

	No. of globules in .0001 cmm.			Relative size of globules.		
Breed test No. 3.	*Jersey.*	*Guernsey*	*Short horn.*	*Jersey.*	*Guernsey.*	*Short horn.*
Herd milk (Av. of Aug. 30-Sept. 2 and Sept. 25-28)................	144	164	162	337	267	214
Av. for milk from single cows (Av. of examinations made Aug. 30-Sept. 23)..	144	166	151	343	262	241
Breed test No. 4.						
Herd milk (Av. Oct. 1-4)...................	156	....	80	309	....	504
Av. for milk from single cow (Oct. 1-4)........	147	....	79	316	....	499

The results are remarkably uniform and illustrate emphatically the correctness of the Babcock method of enumeration of fat globules in cow's milk.

EXAMINATION OF MILK FROM COWS IN THE UNIVERSITY HERD.

The microscopic examinations of the milk of cows in the University herd, begun in 1888 and described in the Sixth and Seventh Reports of this Station, were continued up to the spring of the present year (1894), mainly for the purpose of studying the influence of advancing age on the size and number of the fat globules in the milk of the cows. The investigation was brought to a sudden end by the spread of tuberculosis in our herd, and the subsequent slaughter of all animals but two, and the results may therefore be less decisive than would have been the case if data for a larger number of years could have been secured. The average determinations for the individual cows are given in the following tables and will illustrate the variations in the size of the globules as in the yield of milk and per cent. of fat at different stages of the lactation period, and during subsequent lactation periods.

Fat globules in cows' milk.

NAME.	AT BEGINNING OF LACTATION PERIOD.					AT END OF LACTATION PERIOD.					
	No. of glob.	Relative size.	Yield of milk.	Fat.	Days from calv.	Year.	No. of glob.	Relative size.	Milk.	Fat.	Days from calv.
Sylvia.			lbs.	pr. ct.					lbs.	pr. ct.	
1888..........	161	351	19.80	5 61	31	1889	326	184	4.73	5.97	264
1889..........	128	391	19.88	4.97	13	1890	279	185	18.36	5.11	252
1890..........	139	316	23.44	4.08	12	......	......	......	......	......	......
1891..........	121	383	22.38	4.55	11	......	......	......	......	......	......
Topsy.											
1888..........	108	389	29.46	4.19	62	1889	318	152	14.55	4.82	282
1889..........	163	288	24.50	4.79	12	1890	263	123	15.86	3.20	286
1890..........	104	420	28.22	4.31	12	......	......	......	......	......	......
Bessie.											
1888..........	271	175	18.38	4 72	51	1889	350	186	5.23	6.35	243
1889..........	118	389	25.86	4.39	13	1890	458	116	8.56	5 44	232
1890..........	108	526	19.12	5.56	12	......	......	......	......	......	......
Bunn.											
1888..........	226	141	18.47	3.13	99	1889	317	116	8.80	3.68	249
1889..........	119	317	25.80	3.73	12	1890	424	77	8.74	3.22	245
1890..........	91	431	35.84	3.85	12	1891	302	95	6.62	3.25	334
1891..........	115	331	37.82	3.80	13	1892	322	106	5.40	3.33	295
1892..........	114	385	36.98	4.87	15	......	......	......	......	......	......
1893..........	77	550	30.58	4.25	12	......	......	......	......	......	......
Mattie.											
....	......	......	......	......	......	1890	561	66	13.38	3.68	242
1890..........	178	210	24.90	3.67	12	1891	246	135	16.92	3.26	166
1891..........	166	210	29.14	3.44	28	......	......	......	......	......	......
Beauty.											
1889..........	203	213	24.38	4.37	12	1890	575	89	10.02	5.09	294
1890..........	199	192	22.92	3.79	14	......	......	......	......	......	......
1891..........	189	226	28.26	4.17	17	......	......	......	......	......	......
1892..........	205	207	24.28	4.18	11	......	......	......	......	......	......
1893..........	171	261	24.04	4.46	23	......	......	......	......	......	......
Sylvia H.											
....	......	......	......	......	......	1889	305	241	4.74	7.32	351
1890..........	103	450	24.10	4.62	21	1890	314	160	15.58	5.25	257
....	......	......	......	......	......	1891	305	191	7.22	5.79	298

Fat globules in cows' milk—Continued.

Name.	At Beginning of Lactation Period.					At the End of Lactation Period.					
	No. of glob.	Relative size.	Milk.	Fat.	Days from calv.	Year.	No. of glob.	Relative size.	Milk.	Fat.	Days from calv.
			lbs.	pr. ct					lbs.	pr. ct.	
Governor H.											
1890	108	454	26 26	4.90	12	1889	231	244	2.66	5.75	396
Daisy H.											
1890	131	396	31.66	4.93	17	......	.....	....	....	......	.....
1891	138	326	28.14	4.48	25	1892	356	139	9.66	4.87	332
1892	166	254	29.72	4.18	13	1893	435	142	3.90	6.12	314
Rosette.											
1890	123	378	16.56	4.25	13	......	.....	....	....	......	......
1891	218	244	12.76	5.27	18	1892	282	188	5.46	5.29	294
1892	98	550	19.90	5.38	16	1893	261	208	2.28	5.43	303
1893	95	519	19.32	4.92	11	.....	.....	....	....	......	......
Bessie H.											
1891	131	361	24.02	4 69	12	1892	337	188	9.48	6.24	331
1892	151	345	27.06	5.16	13	......	......	....	......	......	...
1893	169	349	14.40	5.90	24	......	......	....	....	......	......
Gay.											
1890	116	411	21.66	4.48	19	.....	......	......	....	......	.....
1891	118	418	21.74	4 89	10	1892	261	175	9.18	4.60	272
1892	145	383	9.76	5 38	16	1893	179	230	6.28	4 08	241
1893	179	721	28.50	5 04	14	.....	......	....	....	......	......
Galena.											
1890	168	330	31.34	5.54	13	......	......	....	....	......	......
1891	198	206	26.78	4.07	12	1892	404	115	15.56	4.33	288
1892	168	286	26.98	4.66	12	....	.. ..	....	....	......	......
1893	182	267	28.20	4.86	14	.....	......	....	....	......	......
Aaggie.											
1891	132	203	28.66	2.58	13	1892	362	105	1.80	3.72	460
1892	104	286	41.40	2.94	12	1893	390	112	3.30	4.35	329
1893	109	292	43.58	3.17	14	......	......	....	....	......	......
Clothilde.											
....	......	......	....	......	......	1891	409	66	25.24	2.69	119
1892	184	177	40.30	2.47	13	1893	1,124	62	.51	7.14	286
1893	134	218	36.78	2.98	11	......	......	....	....	......	......

Fat globules in cows' milk—Continued.

NAME.	At Beginning of Lactation Period.					At the End of Lactation Period.					
	No. of glob.	Relative size.	Milk.	Fat.	Days from calv.	Year.	No. of glob.	Relative size.	Milk.	Fat.	Days from calv.
			lbs.	pr. ct.					lbs.	pr ct	
Melvina.											
1891..........	213	170	14.25	3.86	29	.....	....	....	....	.....	......
1892..	208	222	13.67	4.58	23	1893	411	93	4.08	3.75	268
1893.....	158	256	19.34	4.05	13	.....	......	....	....	.....	......
Cowslip.											
1892..........	112	382	20.90	4.14	19	1893	315	186	10.60	4.25	379
1894..........	101	452	27.04	4.58	22	......	......	....	....	.....	......
Rue.											
1892.......	112	533	25.54	5.38	13	......	.. ..	....	....	......	... ..
1893..........	63	923	27.08	5.86	15	......	. ...	....	....	......	......

Globules at different stages of the lactation period.—The following table gives average data for the milk from the same cows at the beginning and at the end of the lactation period:

Fat globules in cows' milk.

Name.	At Beginning of Lactation Period.						At End of Lactation Period.				
	No. of lact. periods includ.	No. of globules.	Relative size.	Lbs. milk.	Per cent. fat.	Days from calving.	No. of globules.	Relative size.	Lbs. milk.	Per cent. fat.	Days from calving.
Sylvia	4–2	137	360	21.38	4.76	17	298	185	11.55	5.28	268
Topsy	3–2	125	366	27.40	4.41	29	291	138	15.21	3.98	284
Bessie	3–2	164	363	19.45	4.85	25	404	151	6.90	5.78	263
Bunn	6–4	124	359	30.88	3.92	27	356	99	7.39	3.38	281
Mattie	2–2	172	210	27.02	3.55	20	404	101	15.15	3.45	204
Beauty	5–1	193	220	24.78	4.16	15	575	89	10.02	5.09	294
Sylvia 2d	1–3	103	450	24.10	4 62	21	308	197	9.16	5.75	302
Governor's Heifer	1–1	106	454	26.26	4.10	12	231	244	2.66	5.75	396
Daisy 2d	3–2	145	325	29.84	4.54	18	396	141	6.78	5.23	323
Rosette	4–2	131	423	17.14	4.96	15	271	198	3.87	5.83	299
Bessie 2d	3–1	150	352	21.83	5.15	16	337	188	9.48	6.24	331
Gay	4–2	112	488	20.42	4.89	15	220	203	7.73	4.38	257
Galena	4–1	179	272	28.45	4.73	13	404	115	15.56	4.83	288
Aaggie	3–2	115	260	37.88	2.92	13	376	109	2.55	4.13	395
Clothilde	2–2	159	198	38.54	2.69	12	767	64	12.88	2.77	203
Melvina	3–1	193	216	15.75	4.15	22	411	93	4.08	3.75	268
Cowslip	2–1	107	417	23.97	4.39	21	315	136	10.60	4.25	379
Bessine	1–1	93	542	33.40	5.04	15	259	230	6.82	6.22	355
Bryant	1–1	118	358	29.80	4.15	18	343	148	15.24	4.98	254
Average	......	138	348	26.22	4.26	18	367	149	9.14	4.61	297

The preceding table represents the average of 88 series of determinations of the milk from 19 different cows; we notice that the average number of globules per .0001 cmm. for all cows is, at the beginning of the lactation period, 138, and at its end 367; the average relative size of the globules is 348, and 149 for the beginning and the end of the lacta-

tion period, respectively; the latter figures correspond to a diameter of the average sized globules of .00419 and .00316 millimeters, respectively.

Breeds.—Nine high-grade or registered Jerseys, two registered Holstein-Friesians and two registered Short Horns were included in the foregoing examinations. If the average data for each of these breeds are calculated the results will be as shown below.

Average data for breeds.

Breeds.	No. of cows.	No. of periods.	No. of globules.	Relative size.	Milk yield.	Per cent. fat.	Days in milk.
Beginning of lactation period.							
Jersey	9	22	127	406	25.69	4.74	16
Short Horn	2	5	150	317	19.86	4.30	22
Holstein Friesian	2	5	137	229	38.21	2.80	13
End of lactation period.							
Jersey	9	14	308	185	8.59	5.21	312
Short Horn	2	2	363	115	7.34	3.98	324
Holstein-Friesian	2	4	572	87	7.72	3.00	299

Age of cows.—The milk of six cows was examined at the beginning of four consecutive lactation periods, that of twelve cows at the beginning of three periods and that of sixteen at the beginning of two consecutive periods. At the end of the lactation periods we have a series of three years for two cows and one of two years for eleven cows.

The following table gives the data for the series mentioned:

Fat globules in milk.

AT BEGINNING OF LACTATION PERIOD. Year.	No. of glob.	Relative size.	Milk, lbs.	Fat, per cent.	Day in milk.
Four year series.					
First......	165	304	22.12	4.67	31
Second......	103	295	21.56	4.35	13
Third........	138	365	24.03	4.35	14
Fourth......	131	405	26.75	4.50	12
Three year series.					
First	164	293	22.85	4.38	31
Second	155	302	24.17	4.29	15
Third........	137	357	24.88	4.29	14
Two year series.					
First.........	160	301	24.11	4.19	27
Second	145	339	25 63	4.22	16

AT END OF LACTATION PERIOD. Year.	No. of glob.	Relative size.	Milk, lbs.	Fat, per cent.	Days in milk.
Three year series.					
First.......	311	179	6.77	4 96	300
Second . .	369	119	12.14	4.52	251
Third......	334	147	6.92	4 57	316
Two year series.					
First........	350	147	9 34	4.88	284
Second	397	141	9.13	4.35	269

The study of the preceding table will fail to disclose any striking difference as to the influence of advancing age on the fat globules in milk; the tendency seems to be towards fewer globules and a somewhat larger size with increasing age at the beginning of the period of lactation, and at its end the opposite seems to hold true; the differences found are, however, not very marked.

The results of the examination of the milk from the cows in the Columbian Breed Tests given in the preceding have been carefully studied with reference to the point under discussion. If the cows in the different breeds included in the third and fourth breed tests be separated into three groups according to age, three series of comparisons are at hand, as will be seen in the following table:

Influence of age of cows on fat globules.

Breed.	Age, years.	No. of cows.	Days from calving.	No. of globules.	Relative size.
Jersey	2-3	7	66	144	337
	4-7	7	141	139	415
	above 8	8	137	147	334
Guernsey	3-8	7	121	169	291
	above 8	7	119	174	276
Short Horn	2-5	7	112	105	664
	5-8	7	149	134	529
	above 8	7	112	159	400

The differences in the average distance from calving of the cows in the different groups render somewhat uncertain the interpretation of the results given in the foregoing table; the general tendency, however, seems to be toward a slightly increased number of globules per unit of milk with increasing age, and a similar decrease in the average size of the globules.

THE NUMBER OF INCHES OF WATER REQUIRED FOR A TON OF DRY MATTER IN WISCONSIN.

F. H. KING.

WATER USED BY THE POTATO.

The past season's experiments were made aiming to measure the amount of water required to produce a crop of potatoes at the Station farm. The method adopted was nearly the same as that which has been used for other trials of a similar character already described in the Statio nreports; the important difference being in the mode of applying the water and in not allowing any rain to fall upon the plants during the season.

The galvanized iron cylinders used, eight in number, were 18 inches in diameter and 42 inches deep, and two of these were placed in pits in the potato field with their tops flusn with the top of the soil while the other six stood wholly above ground with their south side screened from the sun by a panel of boards. To keep off the rain, shelters of heavy ducking were made which could be rolled up during the day and put down at night and during periods of rain and this provision was made partly to avoid errors which might arise from irregularities in the amounts of catch of rain, but chiefly because it was proposed to see if potatoes would develop normally without the application of water to the surface.

The method of watering adopted was to set up within each cylinder a column of 3 inch drain tile close against one side and to add water by pouring it into this tube from time to time as needed, taking care always to add no larger quantity at a time than would raise the water in the tile 6 inches above the bottom. All the water these pota-

toes received was therefore procured through capillarity and root action from a depth equal to, or exceeding three feet. The two cylinders in the potato field were filled with soil taken from the same locality and contained the normal moisture of the time and place. The other six cylinders had been filled the year before and used in an experiment to study the effect of potassium Nitrate on the rise of water in soil by capillarity and its evaporation from the surface, and in these the upper 10 inches were simply removed and replaced so as to develop such looseness of texture as results from plowing. Cylinders 1, 2 and 3 had received each 5.333 gms. of Potassium nitrate the spring before and the same amount was added at the time of planting, while the soil of the other three cylinders had received no dressing in 1893 and were given none at the time of planting.

The variety of potato grown in all of these trials was the Alexander's Prolific, and large tubers were selected as nearly uniform in size as could be found and one planted in each cylinder, each potato being cut in two and one half planted each side of the center about 12 inches apart, the planting taking place May 15. The following table gives the weights of the cylinders and the amounts and dates of watering:

Table showing the time of watering potatoes and amounts added.

DATE.	IN FIELD.		CYLINDERS ABOVE GROUND.					
	No. 1.	No. 2.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
May 15	504.0	506.7	581.0	576.5	579.6	579 7	582.0	579.5
Water added	....	....	19.8	18.4	18.2	17.8	17.9	18.3
June 4	500.0	502.3	577.9	574.0	578.1	578.0	578.1	575.9
Water added	10.0	10.0	....	... ...	....	... .	....	....
June 13	497.7	500.0	560.7	559.8	563.0	559.4	557.4	562.1
Water added	10.0	10.0	10.0	10.0	10.0	10.0	10 0	10.0
June 21	496.5	497.9	556.2	553.5	558.1	553.0	552.2	556.8
Water added	13.0	13.0	10.0	10.0	10.0	10.0	10.0	10.0
June 25	502.0	501.4	558.0	554.4	559.6	554.2	554.1	558.7
Water added	10.0	10.0	....	....	....	....	.. ....	....
June 30	487.1	484.4	547.0	542.8	548.7	542.3	543.5	546.5
Water added	10.0	10.0	....	....	....	....	....	....

Table showing the time of watering potatoes and amounts added.—Con.

DATE.	IN FIELD.		CYLINDERS ABOVE GROUND.					
	No. 1.	No. 2.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
July 2	......	......	......	......	......	......	......	......
Water added	10.0	10.0	10.0	10 0	10 0	10.0	10.0	10.0
July 5	484.9	482.6	545.6	541.6	548.0	540.7	542.6	545.5
Water added	15.0	15.0	10.0	10.0	10.0	10 0	10.0	10.0
July 9	478.5	476.7	545 9	540.8	548.6	539.6	542.8	544.4
Water added	20.0	20.0	10.0	10.0	10.0	10 0	10 0	10.0
July 12	476.7	477.2	545.5	538.7	548.1	538.2	541.2	542.8
Water added	20.0	20.0	12.0	12.0	12.0	12.0	12.0	12.0
July 16	475 4	477.9	546.7	538.7	549.4	538.1	542.4	543.1
Water added	15.0	15 0	10.0	10.0	10.0	10.0	10.0	10 0
July 20	475.1	477.6	546.4	536.4	548 8	536.3	541.3	541.2
Water added	15.0	15.0	15.0	15 0	15.0	15 0	15.0	15.0
July 24	479.1	480.2	552.5	539.6	554.3	539 2	548.1	545.9
Water added	10.0	10.0	8.9	7.1	5.2	10.6	12.6	6.0
July 28	476.0	478.7	551.0	532 0	547.9	535.2	543.2	537.3
Water added	15.0	15.0	15 0	15.0	15 0	15.0	15.0	15.0
Aug. 2	478.1	483.2	554.8	531.2	549.2	536.0	550.8	538.0
Water added	10.0	10 0	10.0	10.0	10.0	10.0	10.0	10 0
Aug. 10	476 2	483 3	551.6	524.0	541.5	530.9	545.6	530.2
Water added	15.0	20.0	9 8	22.7	18.0	18.3	15.1	21.7
Aug. 16	486.7	498.2	554.5	533.1	547 4	538 5	552.8	537.5
Water added	......	......	10.0	10.0	10.0	10 0	10.0	10.0
Aug. 25	481.7	492.0	553 3	525.3	538.6	532.3	550.4	529.8
Water added	......	......	8.1	21.4	20.9	16.9	10.3	22.1
Sept. 21	......	......	554.0	527.8	531.6	528.8	545.5	521.4
Water added	198 0	203.0	168.6	191.6	184.3	185.6	177.9	190.1
Soil water	22.3	14.7	27 0	48.7	48.0	50.9	36.5	58.1
Dry matter	.5	.5	.3	.5	.5	.5	.4	.5
Total water	220.8	218.2	195.9	240.8	232.8	237.0	214.8	248.7

The potatoes in the two field-cylinders matured first and were dug August 25, while the others remained until September 21; but all of them, including those of the field in which the experiment was conducted, were very evidently injured by a blight. Only in cylinder No. 2 of the field

trial were the tops entirely dead when the potatoes were dug.

The following table gives the weight of tubers produced in each case and the computed yield per acre:

Cylinders in the ground.

	WEIGHT OF TUBERS.			YIELD PER ACRE.		
	Merchantable.	Small.	Total.	Merchantable.	Small.	Total.
No. 1	1.308	.386	1.694	537.3	158.5	695.8
No. 2	.817	.775	1.593	335.6	318.3	653.9

Cylinders above ground.

No. 1	.452	.539	.991	185.6	221.5	407.1
No. 2	.379	.792	1.171	155 7	325.5	481.2
No. 3	.322	.875	1.197	132.4	359.2	491.6
No. 4	1.024	.314	1.338	420.6	128.9	549.5
No. 5	.709	.282	1.091	291.2	156.9	448.1
No. 6	.681	.435	1.116	279 9	178.8	458.7

The yield of dry matter was determined in each of these cases and for the cylinders above ground for the tops and tubers separately. The total dry matter and the relative amounts of water used are embodied in the table below:

Table showing the amounts of water used by the potato.

	Dry matter	Water per pound of dry matter	Dry matter per acre.	Acre-in. per ton dry matter	Total water used.
	lbs.	lbs.	lbs.	inches.	inches.
No. 1	.513	430.4	12,650	3.80	24.02
No. 2	.5258	415.0	12,960	3.66	23.74
No. 1	.3338	586.9	8,248	5.17	21.31
No. 2	.5007	480.9	12,340	4.25	26.20
No. 3	.4505	516.8	11,110	4.56	25.33
No. 4	.5020	472.1	12,370	4.17	25.78
No. 5	.3596	497.3	8,865	5.27	23.37
No. 6	.5425	458.4	13,370	4.05	27.06

It is evident enough from this table whatever may be said regarding the yields of dry matter, that the potatoes did use a very large amount of water, in fact a quantity three times the amount of the rain which fell during their period of growth and since the surface of the ground was kept dry through the whole season very much the larger proportion of the water must have passed through the vines and only a small part could have been lost through the soil directly. The amounts of water used in proportion to the dry matter produced must be held, for the present at least, as likely to be too high because the blighting of the leaves may fairly be expected to have diminished the production of dry matter. It will be much safer to use the figures derived from the two cylinders standing in the ground in the potato field as indicating the amount of water a field crop may be expected to use and yet these must be held as probably too high.

The ratio of dry matter in the top to that in the tubers was, for the six cylinders above ground, as 211 to 237, so that the production of a crop of 200 bushels means the growing of more than 4,500 pounds of dry matter and this would require at the mean rate of the first two cases in the table above 8.39 inches of water properly distributed and well utilized. In the case of such crops as the famous one of the late J. M. Smith where he took 1,734 bushels from four acres of ground the amount of water needed, if used at the above rate, would be about 18.5 inches, and this is not beyond the possibilities of natural supply in very favorable seasons and with careful saving.

It will be seen that the average computed yield per acre given in the table on page 243 is, for the plants in the cylinders in the ground, 436 bushels of merchantable potatoes and 674 bushels as the total yield, but the two hills grew on only 1.767 sq. ft. Had this seed been planted 30 in. one way by 12 in. the other, the yield per acre with no better growth, would have been 238 bushels, and this means that these hills were not as good as the average in the field of Mr. Smith.

In a field trial this year where a portion of the field was irrigated and another portion not, as described on page 258

the same variety of potatoes were planted 30 in. one way and 15 in. the other, producing the yields given below:

SURFACE IRRIGATED.			NOT IRRIGATED.			SUB-IRRIGATED.		
Large.	Small.	Total.	Large	Small.	Total.	Large.	Small.	Total.
117.7	17.2	134.9	80 1	8 8	88.9	107.0	12.3	119.3

The amount of water used in these cases, counting simply that added and the rainfall, was, for the surface irrigated land, 16.76 in., for the not irrigated, 8.15 in., and for the sub-irrigated, 21.87 in.

In another trial, under the conditions described on page 257, the sub-irrigated yield was 69.8 bushels, while that not irrigated was only 33.5 bushels per acre.

It is plainly evident from these field trials that the water added had a very beneficial effect upon the crop, the surface irrigated yield being 51.7 per cent. greater than that on the not irrigated check plots, and the sub irrigated yield 34.2 per cent. greater; while on the gravelly knoll the watered area gave 108.4 per cent. more than did its control plot, and the experiments serve to indicate that when the large water resources which are now running to waste through our extensive potato lands become to be utilized by methods of irrigation, as they evidently will be some time, much larger and more certain returns from these lands will be realized than are now possible. They also indicate that such careful and thorough cultivation of lands not irrigated as will conserve so much of the natural water supply as is possible must tend to diminish the ravages of blight and of insect enemies.

It appears not a little strange that the three cylinders to which the potassium nitrate had been applied gave no evidence of having profited by its use. Indeed, the yields were actually less than the figures given below indicate:

Table showing the amount of dry matter produced by the potatoes in the six cylinders above ground.

POTASSIUM NITRATE.			NO NITRATE.		
	Tubers.	Top.		Tubers.	Top.
	gms.	gms.		gms.	gms.
No. 1	75.5	77.7	No. 4	112.2	115.5
No. 2	99.1	128.0	No 5	87.2	76.1
No. 3	97.2	107.0	No. 6	104.4	141.7
Sums	271.8	312.7		303.8	333.3

It may perhaps be urged that since the soil in these cylinders was fallow the season before they may be assumed to have developed an over abundance of nitrates so that no advantage should be expected from the nitrogen added but so far as the potash is concerned the remark could hardly apply with the same force, especially in view of the large demand made upon the soil. It will also be seen that the the amount of water required for a pound of dry matter was greater in the soil treated with the potassium nitrate than in the other case although the total evaporation was 31 pounds less from the three nitrate cylinders than it was from the other three. It cannot therefore, be said that the soil richest in nitrogen and potash increased the productiveness of the water used.

WATER USED BY OATS.

In four cylinders similar to those used in the potato experiment, oats were grown, the cylinders standing in pits with their tops flush with the surface of the ground and in a field of oats. They stood in two pairs and to the surface of No. 1 in each set land plaster was applied at the rate of 200 lbs. to the acre, the object being to see if the lime sulphate, to any measurable extent, affected the amount of water used.

In these cases, too, as with the potatoes, all rain was excluded and water was applied only at the bottom through columns of 3 inch tile as already described.

In the following table are given the amounts of dry matter produced and of water used together with the results obtained in previous years:

Table showing the amount of water used by oats.

	Water used.	Dry matter.	Water per lb. of dry matter.	Dry matter per acre.	Acre-in. of water per ton of dry matter.	Total water used.
1891.	Pounds.	Pounds.	Pounds.	Pounds.	Inches.	Inches.
No. 1........	224.25	.4405	509.3			
No. 2..........	220 7	.4471	493.6	8,861	4.444	19.69
1892.						
No. 1..............	174.6	.3822	525.6	8,189	4,640	19.00
1894.						
No. 1............	282.8	.5232	540.6	12,900	4,770	30.77
No. 2..............	280.2	.5163	542.7	12,730	4,789	30.48
No. 1..............	283.3	.4198	674.9	10,850	5,956	30.82
No. 2..............	286.6	.4663	614.7	11,500	5,424	31.18

It will be seen from this table that while the total yield of dry matter was much larger in 1894 than in the other two years, the amount of water used was also relatively higher, the three trials of 1891 and 1892 averaging 509.5 lbs. of water for one pound of dry matter, while the average for the four cases in 1894 is 593.2 pounds of water to one of dry matter; the general average of the seven trials being 557.3 pounds to one.

The cylinders in which the oats were grown were weighed several times after the crop had been removed to learn how rapidly the water might pass away from the naked soil. To avoid any action of the roots through the stubble, these were pulled. It was found that during an interval of 23 days from Aug. 2 to 25, the total evaporation from each cylinder was 1.3, .9, 1. and 1. lbs respectively, from which it is evident that nearly all of the water left these cylinders through the plants growing in them. If it be assumed that water was lost through the soil during the growing period at a mean rate equal to that which was

observed after the crop was removed, the amount lost in this manner would be 4.33 lbs. for each cylinder, which would decrease the amounts of water per pound of dry matter given in the table by about 10 pounds in each case for 1894.

These observations regarding the consumption of water by the oat plant serve to emphasize the point which has been urged before regarding the extreme drying of the soil by this crop, thus making a catch of clover more difficult with it during dry seasons.

If we put in condensed form all the observations made at this Station regarding the amount of water required for a pound of dry matter, we shall have the results given in the table below:

Table showing the amount of water required for a poand dry matter in Wisconsin.

	No. of trials	Water per pound of dry matter.	Dry matter per acre.	Acre—inches of water per ton of dry matter.
Dent corn	4	309.84	19,515	2.64 in.
Flint corn	4	233.2	25,099	2.14 in.
Red clover	3	452.8	9,613	4.03 in.
Barley	3	392.89	10,819	3.43 in.
Oats	5	557.34	10,755	5.02 in.
Field peas	1	477.37	8,017	4.21 in.
Potatoes	2	422.7	12,805	3.73 in.

It must be understood in considering these results that they apply to trials made under conditions where none of the water used could be lost by percolation and that in irrigating very open soils, more water would be required unless applied in small quantities at a time.

FIELD EXPERIMENTS ON THE PERCOLATION OF WATER AS RELATED TO IRRIGATION.

F. H. KING.

In the development of methods of irrigation for humid and semi-humid climates it is needful that more should be known regarding the rate of movement of water downward, laterally and upward both by percolation and by capillarity, and to this end experiments have been conducted during the past two years aiming to throw additional light upon this subject.

OBSERVATIONS ON THE RATE OF PERCOLATION OF WATER FROM A SYSTEM OF TILE DRAINS.

We have at the Station farm a system of tile drains covering an area of about five acres, in which the total measured length of tile is 7,022 feet, distributed in the manner indicated in Fig. 25.

These tile are laid at a mean depth of about four feet in a soil which consists of 6 to 8 inches of a medium clay loam at the surface, followed by 2.5 to 3 feet of clay, and below this a rather coarse sand in the upper portion of which the tile are laid. In the solid square shown in the figure the lines of tile are 33 feet apart, but the laterals leading into the main extending from A to the lake have a greater distance. Advantage has been taken of this system of tile drains to study the rate of percolation and of capillary movement of water under field conditions in the soils of this area.

The first experiment was begun on August 2d, 1893, at which time a small rotary pump, having a capacity of

about 100 gals. per minute, was connected with the outlet of the drainage system at the lake, which is terminated by a 16 foot length of 6 inch steam pipe.

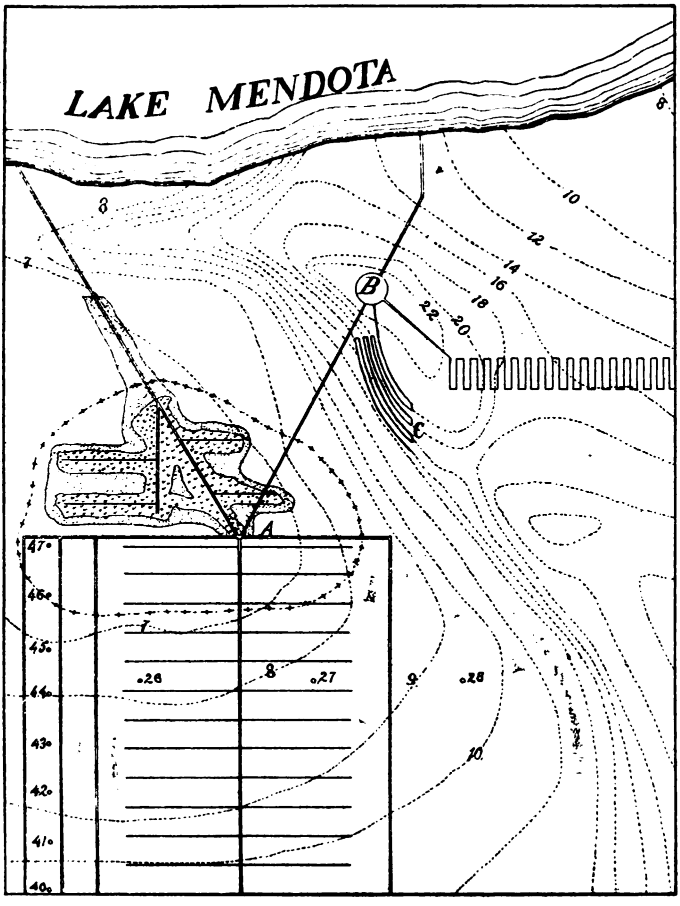

FIG. 25.—Showing the distribution of tile drains used in the study of field percolation.

After pumping 33 hours during portions of four consecutive days it became evident that the rate at which water could leave the lines of tile and percolate laterally and vertically through the soil was much slower than had been anticipated, and also that it was possible with this small pump to hold the water at a level in the silt well A within one foot of the surface of the ground, and this too when the water was setting back into and percolating from nearly the

whole system of 7,022 feet of drain tile. On account of the rise in the ground the most distant portions of the drains leading into the silt well A are only a little below the top of the ground at the well so that at the time of this pumping but little water reached the more distant portions of these tile, and hence the percolation was chiefly confined to the lower two-thirds of the drains in the solid square.

To ascertain the extent to which the water moved laterally from the drains two methods of observation were adopted as follows:

Systems of 4-inch auger holes were put down at varying distances from the lines of tile and in different portions of the area under experiment in which the hight of the ground water could be determined by direct measurement. The second method consisted in taking samples of soil in one-foot sections to a depth of four feet along lines parallel with but at different distances from the drains and then determining the amount of water these samples contained when taken before and after the close of the experiment.

Through the systems of auger holes and twelve permanent wells, situated both within the area under experiment and outside of it, it was learned that water forced into the tile drains actod by direct hydrostatic pressure upon the ground water, causing this to rise through the soil and tend ultimately to stand on a level with that at which the surface was held in the silt well at A. The water rose most rapidly and highest near the lines of tile and in those portions of the field where the tile were lowest. After the pumping stopped the water would fall in the silt well, but continue to rise in the ground where the water was lower until the surface of the ground-water had attained a nearly horizontal attitude on a higher plane than that held by the lowest portion at the time pumping began.

Through the sampling of the soil it was learned that during the eight days following this first experiment, the outlet of the drain having been kept closed, the water content of the soil changed as indicated in the table below:

Above two lines of tile—

The surface foot lost	2.1 per cent
The second foot gained	1.4 per cent
The third foot gained	3.4 per cent
The fourth foot gained	2.4 per cent

Eight feet from the two lines of tile—

The surface foot lost	.6 per cent
The second foot gained	1.3 per cent
The third foot gained	4 1 per cent
The fourth foot gained	3.1 per cent

Sixteen feet from two lines of tile—

The surface foot lost	1.6 per cent
The second foot lost	.5 per cent
The third foot gained	3.5 per cent
The fourth foot gained	.3 per cent

The samples from which these results were determined were each composites of five taken at equal intervals along lines above and between the two lateral drains lying just to the southeast of silt well A.

As there had been no rain during this interval and as a crop of clover was growing upon the ground at the time it is evident that considerable water had been given to the fourth, third and second feet of soil, not only above but midway between these lines of tile and, it is also more than probable that a not inconsiderable amount must have reached the surface foot as well.

A second experiment performed in 1893 consisted in shutting off the silt well A and the lines of tile leading into it and thus confining the water pumped from the lake to the 755 feet of tile between this point and the outlet.

After pumping continuously during eight hours on October 11 and then three hours ten minutes the next morning it was found that the whole area covered by the heavy shading in Fig. 25 had become thoroughly wet to the surface, in many places the water even standing upon the ground, and that the lighter area was saturated to within 12 to 14 inches of the surface. While the pumping was going on the water was held in a standpipe at the silt well at a hight of about one foot above the level of the surface of the ground into which the water was percolating, and the experiment served to demonstrate that under certain conditions it would be possible to completely saturate a tile

drained field by pumping water through the main, allowing it to set back into the laterals and rise by hydrostatic pressure and capillarity to the surface.

The amount of water pumped into the tile drains during these two experiments could not be measured with any trustworthy accuracy, but the present season the experiments have been repeated with a larger pump lifting water into a reservoir at B, Fig. 25, 40 feet in diameter and nearly two feet deep, from which water could be conveyed to the silt well A through a 5 inch sewer pipe laid just below the surface, and thus a more definite idea of the quantity of water used, be gained.

The first trial with these arrangements was made on July 11, and at this time the water was admitted only to the tile in the solid square, those between the silt well A and the lake having been shut off by means of a plug screwed into an elbow placed upon a 20-foot length of steam pipe forming the first portion of the main leading away from the well toward the lake.

To measure the water admitted to the system the reservoir was first nearly filled and the time required to lower the level of the water in the reservoir two inches was noted, from which the rate of discparge became known. The outlet of the reservoir was again closed and the pump started. When the water in the reservoir had been raised one inch, or to the mean height through which it had fallen, the plug was withdrawn and the rate of pumping controlled so as to hold the level of the water in the reservoir constant; and under these conditions the rate of discharge has been assumed uniform, and the amount of water delivered to the field obtained by multiplying the rate of discharge by the time.

The amount of water admitted to the system of tile drains on this day was computed to be 11,743 cu. ft., the pump stopping at 5:55 p. m., and the reservoir being allowed to empty itself after that. While this water was running the level of water in the silt well A was held at the top and about one foot above the surface of the ground at that place.

Samples of soil were taken before pumping began and again July 13 midway between the two lower lines of tile in a field of corn to the southwest of the silt well, and the results showed that the surface two feet at this time contained 1.35 lbs. and the second two feet 8.18 lbs. more water than when pumping began, or a gain of 9.53 lbs. per sq. ft., which is equivalent to 1.83 inches. This amount of water was not, of course, given to the whole area covered by the drainage system because on account of the slope of the land most of the water was confined to the lower half. Water enough was pumped to cover the whole field to a depth of about .9 inches had it been uniformly distributed.

On July 25 water was again admitted to this system during 10.5 hours at an estimated mean rate of 1,810.69 cu. ft. per hour, thus making the total amount 19,012.25 cu. ft., or 1.42 inches for the whole area of tile system. On July 26 the mouth of the main drain at the lake was closed and water admitted only to that portion of the tile between the silt well and the outlet, beginning at 8:35 a. m. It was very soon found that these tile could not take the water as rapidly as it was being delivered, and the line leading to the three north and south laterals on the west side was opened, but the well soon overflowed and the plug was then withdrawn from the south main leading into the silt well. With this open the water fell at first, but at 11 a. m. it again stood within 2.5 in. of the top and the surface of the ground began to show wet along the main leading to the lake. The pump was stopped for dinner, started again at 1 p. m. and at 2 the well was full. At this time the water was admitted to the east inlet, and from now until 6 p. m. water was carried to the whole system of 7,022 feet of tile, the mean flow being at the rate of 49.67 cu. ft. per minute, which makes a rate of percolation amounting to 5 gals. from each 100 feet of tile per minute.

The total water admitted to the area during the day was 26,018 cubic feet, and during the two days 45,030 cubic feet. At night the surface of the ground was wet along all the tile below the silt well for a width of about 8 feet, and on the evening of July 27th, 56.5 hours after pumping began,

the level of the ground water had changed the amounts indicated below as shown by measurements of the wells before pumping began and at the time stated above:

Wells.	28	27	26	47	46	45	44	43	42	41	40	A.
Change, inches	8.02	14.3	13.43	15.73	11.2	10.35	8.49	4.03	3 69	2 35	1.74	13.97

The positions of these wells is indicated by number in Fig. 25. It is not possible to give exact limits to the area over which the ground-water was raised, but it could not have been less than 7 acres and over the area limited by the tile drains, which is five acres, the mean elevation of the water-table must have been as much as 8 inches. The amount of water pumped into the drains, if applied to the surface of 5 acres, would cover it to a depth of 2.07 inches.

It was shown in the Sixth Annual Report of this Station, p. 198, that the capacity for water of the 3rd and 4th feet of undisturbed soil near well 28 when lying below the water table was .5 inches more than when lying one foot above the water table, and if we suppose these two feet of soil to have been fully capillarily saturated the water added was sufficient to raise the level much more than 8 inches, the observed amount. If the third foot were only 75 per cent. capillarily saturated and the fourth foot fully so then the water added should be sufficient to raise the water-table more than 2 feet. If we suppose the third and fourth feet each 75.0 per cent. saturated the water added will still be sufficient to raise the water-table considerably more than a foot over the whole five acres. It is not strange, therefore, that so small an amount of water should have affected the water-table to the observed extent over so large an area, and it follows further and without such direct observations as have been recorded above, either that a large capillary rise of water into the dryer soil above must have taken place or else there must have been a large under flow of water out of and beyond the limits of the field under experiment. We do know from direct observation that portions of this water did even reach the surface, and that much of it entered the second foot over fully two acres of ground.

On September 6, after the crops had been removed, another trial was begun, the object belng to ascertain how long and how much water would be required to saturate the soil of the tile-drained area. There were consumed in actual pumping during the trial 32.5 hours and water was discharging into the silt well 36.5 hours. The pumping began at 3:45 p. m. September 6, and closed 5:45 p. m., September 11, Sunday intervening. During this time there was pumped 105,272 cubic feet of water, enough to cover 5 acres 5.8 inches deep. The amounts of water pumped on the respective days are as follows:

Sept. 6	6,173 cubic feet.
Sept. 7	24,190 cubic feet.
Sept. 8	25,990 cubic feet.
Sept. 10	30,126 cubic feet.
Sept. 11	18,793 cubic feet.
Total	105,272 cubic feet.

The mean rate of percolation from this drainage system into the soil was:

$$\frac{105{,}272}{60\times 36.5}=48.07 \text{ cubic feet}$$

per minute or about 5 gals. for each 100 feet of tile in the same time, an amount almost identical with that obtained from the trial of July 26. These results are a small but an unknown amount too large owing to the fact that the joints of the sewer pipe through which the water was conveyed from the reservoir to the silt well, although laid in cement were not quite water tight, and some water escaped from this conduit before reaching the silt well, but this amount when compared with the whole water moving was certainly small, much less than one per cent. and probably less than one-tenth of one per cent.

Measurements of the height of the ground-water before the pumping began and again two days after the pumping stopped showed that there had been a rise of the following amounts at the several wells:

Wells	40	41	42	43	44	45	46	47	26	27	28	A.
Rise, inches	6.5	8.8	8.1	17.2	26.3	32.2	31.7	35.9	33.4	35.0	18.1	40.6

When pumping began the water-table sloped 1.9 inches from well 28 toward the silt well A, Fig. 25, but when measured two days after pumping the slope was in the opposite direction and in amount 20.6 inches. So with well 40 while the slope was toward A to the extent of 12 inches before pumping it was, two days after pumping, 23.5 inches in the opposite direction.

When the pumping stopped the ground within the area bounded by the line of crosses was saturated with water very nearly or quite to the surface and outside of this the water had been raised by capillarity varying amounts over the whole area occupied by the tile.

RATE OF PERCOLATION FROM SUB-IRRIGATION TILE.

On the western slope of the hill at C and on the eastern side at D, Fig. 25, were laid two system of tiles, 18 in. below the surface where the percolation could be studied under conditions where the surface of the ground was from 16 to 20 ft. above the water table. At C the tile are laid nearly along contour lines 5 to 7 feet apart and connected in a zigzag manner as shown in the figure. On the other side the tile are also laid in a zigzag manner but ten feet apart, each line being 30 feet in length. These plots were experimented with at several times during July and August when corn was growing upon the ground, and also in September after the crop had been removed.

During the first trial on plot C where the length of tile is 1,020 feet the rate of percolation was 10.6 gals. per minute for each 100 feet of tile, and during another trial in September after the crop was removed the system took water at the rate of 14.72 cu. ft. per min. or 10.79 gals. for each 100 feet of tile. The soil at this place is a sandy reddish clay and gravel underlaid at 2 to 3 feet with coarse sand and gravel very pervious to water.

On plot D, where there is a more impervious reddish clay sub-soil, the rate of percolation, even when most rapid, was less, the 1,350 feet of tile taking, in 11.18 hours, 9,878 cu. ft. of water, or at the mean rate of 5.98 gals. per minute for each 100 feet of tile.

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During these experiments the water was held in the systems of tile C and D under a pressure which caused it to rise in open pipes, placed above the lines, to the level of, or a little above, the surface of the ground, and under these conditions the soil first became saturated to the surface immediately above the tile and then spread laterally, but during the summer trials, when the crops were on the ground, the saturation of the soil at the surface only occurred in a few places, in the case of plot C the ground usually became saturated to within 2.5 to 3 in. of the surface above the lines of tile and to within 9 to 11 inches of the surface midway between them. In the September trial this plot was completely saturated to the surface over more than three-fifths of the area, but to do this 23.7 inches of water were required, an amount considerably more than the surface four feet of this particular soil was capable of retaining by capillary power.

It should be stated here that experiment proved the rate of percolation from the 3 inch tile on the hillside at C too rapid to allow the water to be forced through the whole system by the zigzag method contemplated and that after the first trial the seven lines of tile were connected at the end next to the reservoir so that water entered the several lines at the same time. To prevent more than the due amount of water entering the lower line of tiles the connecting line was partly closed by slipping between two lengths of tile a piece of sheet iron.

INFLUENCE OF THE WATER PUMPED ON THE YIELD OF CROPS GROWING ON THE AREA.

To note the influence of sub-irrigation upon vegetation, corn was planted upon the three areas under experiment and the yields carrefully noted.

The hillside on which plot D is located was divided into five parallel strips each thirty feet wide; the sub-irrigated strip occupying the middle position. On either side of this a strip of like width was surface irrigated and still outside of these the remaining two plots received only the rains of the season.

This ground was a clover sod plowed in the spring, to which a dressing of well rotted manure equal to forty-four loads to the acre was applied.

After fitting the ground the corn was planted in rows both ways 30 inches apart from east to west and 15 inches the other way, dropping from three to five kernels in a hill. The object in planting the corn so close upon the ground was to ascertain whether it was possible by irrigation to produce yields at all comparable with the very heavy ones which had been obtained each season for three years in the large pot experiments having for their object the determination of the amount of water required to produce a pound of dry matter. The field was harrowed once before and once after the corn came up and cultivated three times one way from north to south across the several plots and in the usual manner. The western half of the field was planted to a variety of flint corn and the eastern to the Pride of the North dent; then each of these portions was further subdivided by thinning alternate ten rows to two stalks in a hill, while the other ten rows retained from three to five. Between the two pieces of corn were planted six rows of potatoes in hills the same distance apart as the corn.

No irrigation was done until after the corn was too large to cultivate, the first water being applied on July 10. To convey the water to the two surface irrigated strips a line of three inch tile was laid along the south margin of each, just flush with the surface of the ground and the water was allowed to flow out between the rows of corn, escaping from the joints of the tile. To control the flow of water from tile, pieces of galvanized iron were slipped into the joints, here and there, thus more or less completely stopping the flow beyond.

The total amount of water put upon the three irrigated plots is accurately known, but there is a considerable uncertainty regarding the division of it between them, owing to difficulties in handling the water at first, but the table given below expresses very nearly the true distribution of water and the amount used:

Table showing the amounts of water used on field D.

	Not irrigated.	Surface irrigated.	Sub-irrigated.
Season rain	8.15 in.	8.15 in.	8.15 in.
Water pumped	....	8.61 in.	13.72 in.
Total	8 15 in.	16.76 in.	21.72 in.

The yields of dry matter per acre were as follows:

	Not irrigated.	Surface irrigated.	Sub-irrigated.
Flint corn	7,916 lbs.	11,080 lbs	9,545 lbs.
Dent corn	7,426 lbs.	9,625 lbs.	7,907 lbs.

These plots, which were 30 ft. by 325 ft., each received identical treatments in every way except in the matter of water put upon the ground. It will be noted that both irrigated plots gave larger yields than did the ground receiving no water, the combined mean difference being as 7671 to 9539, the irrigated being 24.4 per cent. greater than that not irrigated. This difference in favor of the larger amount of water is some less than the true amount owing to the fact that about 10 per cent. of the heaviest portion of the irrigated corn was left to mature its ears while the other was cut and put in the silo, the latter only being included in the statement above; so too, the difference between the surface and sub-irrigated corn appears in the table larger than it really is because one-half of the reserve corn came from the single sub-irrigated plot while the remaining half was apportioned between the two surface-watered plots.

This reservation was made on account of the fact that in our anxiety not to apply too much water for fear of injury from possible rains too little was given and the result is an average yield much too small. There was a strip along the line of the surface distributing tile which received more water than the balance of the plots and here the yield was

very much better than the average. There was also a more level portion extending across two of the plots which resulted in giving more water to these portions, and here too the corn was far superior to the rest. A strip 6 hills wide and 325 feet feet long, extending along each side of one of the conducting tile, was reserved to husk, and also a section of ten rows across the sub-irrigated and surface irrigated plots. When ripe and husked the corn along the line of tile gave a yield of ear corn of 72 pounds to the bushel, as follows:

	Per acre.
Flint corn, thick seeding	98.6 bu.
Flint corn, thin seeding	119.7 bu.
Dent corn, thick seeding	51.8 bu.
Dent corn, thin seeding	64.9 bu.

The surface irrigated plot of flint corn gave a yield of 107.1 bushels and the sub-irrigated 104.2 bushels.

All of this corn was thoroughly kiln-dried after husking and then shelled, giving the following results:

	Per acre.
Flint corn, surface irrigated	73.3 bu.
Flint corn, sub irrigated	71.9 bu.

In the other case, along the line of the tile, the results stood:

Flint corn, thick seeding	67.71 bu.
Flint corn, thin seeding	83.53 bu.
Dent corn, thick seeding	35.51 bu.
Dent corn, thin seeding	49.83 bu.

For some reason the dent corn not irrigated produced no ears and the flint corn only a few small and imperfect ones. Even on the areas best watered not all stalks bore ears, while many of those produced were incompletely filled, the kernels at the butts being often wholly or largely absent. The figures above also show that the largest amount of shelled corn was produced on the plots having only two stalks in the hill. The converse of this, however, is true when we compare the total dry matter produced, as is shown below:

	FLINT CORN.*		
	Not irrigated per acre.	Surface irrigated per acre.	Sub-irrigated per acre.
Thick seeding.	8,889 lbs.	11,980 lbs.	9,877 lbs.
Thin seeding	7,804 lbs.	9,697 lbs.	8,899 lbs.
Difference.	1,085	2,283	978

In the case of plot C, only dent corn was planted and only sub-irrigation compared with the crop produced under the conditions of the natural rainfall. The corn was planted in north and south rows 30 in. wide with hills of three to five stalks 15 in. apart in the row. Here also the corn not irrigated produced no ears, and that watered only relatively few small and imperfect ones. The yield of dry matter per acre was:

Sub-irrigated	8,614 lbs.
Not irrigated	4,679 lbs.

The total water used in this trial, including the season's rainfall, was 31.72 inches, but from this there should be deducted 4.5 inches which was applied in excess and allowed to percolate at once beyond the reach of the roots, thus leaving the water to be charged to this crop as 27.22 inches.

On the tile drained plot, where the corn was planted, the yield per acre was as stated below:

	Per acre.
Flint Corn—	
Dry matter	7,799 lbs.
Shelled corn	57 81 bu.
Dent Corn—	
Dry matter	9,187 lbs.
Shelled corn	63.05 bu.

In these cases the rows were planted three feet apart with hills of three to five stalks eighteen inches from center to center, and the dent corn occupied the north end of the plot where the water came nearest to the surface, and it is because of the larger water supply resulting from this posi-

tion that the dent corn produced a larger yield than the flint, which under like conditions, with us, has given the largest returns.

A field of dent corn adjoining this, but upon land which had been in pasture for several years and was in good heart gave a yield of 6,115 lbs. of dry matter and only fifty-three bushels of shelled corn to the acre, an amount 50.24 per cent. less for the dry matter and 18.31 per cent. less for the shelled corn. It should be said, however, that this corn was drilled in and not planted as thick. Another field on new land but higher ground which had been in pasture for years, gave only 5,066 lbs. of dry matter to the acre.

In still further evidence of advantage derived from the water introduced into these tile drains may be cited the results of a comparison of yields of six rows of hills taken along the line of tile with six others taken midway between them. In thecase of the flint corn the yield above the tile was 74 bushels of ears of 72 pounds each, while that midway between was 64 bushels or 15.6 per cent. less. With the dent corn the yield above the tile was 73 bushels, while that midway between was 60 bushels per acre, an amount 21.7 per cent less.

The beneficial effect of irrigation upon potatoes has already been cited on page 245.

On the ground between the silt well A and the lake, Fig. 25, the effect of sub-irrigation was very marked upon the clover of this year's seeding where it grew very rank and thick. In the upper portion of the eastern half of the tile drained system where the water did not come nearer than 3 to 3½ feet of the surface by hydrostatic pressure the location of the tile became evident from the stronger growth of second crop clover.

Just why the thick seeding of corn failed to ear normally is not evident in view of the facts at hand. In the case of the large pot experiments where the pots stood in the corn field, less than nine-tenths of a square foot of surface repeatedly produced large normal stalks and ears, giving yields as high as 34,730 lbs. or 17 tons of dry matter to the acre. In the thickest seeding in the field this season the

root room was nearly equal to that in the pots and the soil was in much better heart in all cases, and yet the largest average yield here was not quite one-third of that cited. The standing room in the air and sunshine was less in the field trial, but even marginal rows in the field failed to develop normally.

It is true that while 34.23 inches of water were used in the pot experiment under conditions where none of it could be lost by percolation, only 16.76 inches were used in the field where some part of it may possibly have passed downward beyond the reach of root action. There was a portion of the surface irrigated ground, on which the flint corn grew, measuring more than 2,400 square feet, which did produce over 29,000 lbs. or 14.5 tons of dry matter to the acre, and a very large, though not normal, proportion of ears, but it is quite certain that this area received more than 16.67 inches of water, just how much can only be conjectured.

One object of these experiments was to learn how much closer than the general practice of field planting corn may be grown provided ample water is furnished, and the results appear to warrant the conclusion that with more water supplied and less wasted a considerably closer stand and much larger yield may be had, and it is safe to say that as land values advance large areas of ground devoted to the raising of corn and potatoes and other field crops will be made to utilize portions of the abundant water of comparatively humid climates which now passes unused in many streams or lies idle and an obstacle to progress in a thousand lakes and marshes.

COST OF PUMPING WATER.

In raising the water from the lake for these experiments a No 4. centrifugal pump was used, driven by a common portable farm engine. The water was drawn through a 6 inch suction pipe 110 feet long, raised to a height of 26 feet and conveyed by gravity to the reservoir through a 6 inch galvanized iron conductor pipe.

During three days the coal used in pumping was weighed and the amount burned on the 8, 10 and 11 of September was 1,865.1 lbs. of Indiana block, pumping with it 74,909 cubic feet of water or at the rate 80,320 cu. ft. per ton of soft coal, equal to 22⅛ acre-inch. Had we been provided with a larger discharge pipe and facilities for using water more rapidly than was possible at the time, the same amount of fuel would have been able to raise much more water than it did under the unfavorable conditions of the experiment.

CULTIVATION OF CORN THREE INCHES DEEP COMPARED WITH A LESS DEPTH.

F. H. KING.

During four consecutive seasons experiments have been made aiming to establish the best depth of stirring the soil in the cultivation of corn. There have been conducted in all twenty experiments bearing upon this question, thirteen of which have been on the Station farm and seven in different portions of the state, as follows:

Two by Mr. A. F. Noyes, Beaver Dam, Dodge Co.; one by Mr. Geo. Wyley, Leeds, Columbia Co.; one each by Mr. E. C. Herrick, Plainfield, Portage Co.; Mr. Chas. Diener, Stephensville, Outagamie Co.; Mr. Herman Kohlwey, Grafton, Ozaukee Co.; Mr. Fred M. Balsley, Fayetteville, Walworth Co., and Mr. Grant Austin, Milton, Rock Co. The last five gentlemen have been Short Course students at the university. Neither Mr. Wyley nor Mr. Noyes need an introduction here. It is due these gentlemen to state that the several experiments have been conducted with great care and without other compensation than comes from the satisfaction of having helped in the establishment of truth.

PLAN OF THE EXPERIMENTS.

In all these experiments the same general plan has been followed and two depths only have been tried, always under field conditions, where the ground planted to corn usually exceeded one acre. Three inches has been adopted as the maximum depth in these trials and one to one and a half inches as the minimum. The trial plots have consisted of alternating groups of four rows, one set cultivated deep and the other set shallow. Cultivation three inches deep

means, in these trials, such that when the loosened soil is brushed away the points of the teeth have a measured vertical depth of three inches below the unstirred soil.

The comparative yields have always been determined by weighing the whole product of the two middle rows of each group of four and when only twelve rows extending through the field have been entered for competition these have been located upon a section where all conditions were as nearly uniform as possible and the yield of the two center rows of the middle plot has been compared with the mean of that of the two center rows of the adjacent plots on either side. Where dead furrows and back furrows extended in the same direction as the rows of corn care has been taken to avoid them, and when whole fields have entered into the trial these have been cultivated throughout in alternate groups of four rows deep and four shallow, the yields of the middle two rows of each always and only entering into the comparison and outside rows and end hills have been rejected. The early cultivation of these trial rows has consisted in the common harrowing of the whole field before and shortly after the corn was up and in the later cultivation the aim has been to run close enough to keep the corn clean without the aid of the hoe. Of course cultivation but one way could be followed in these trials.

EXPERIMENTS AT THE STATION FARM.

In our first experiments in 1891 the Deere Eagle Claw cultivator was used the latter part of the season and the Deere Spring Tooth during the early portion. The corn was planted May 29 in rows 3.5 feet one way and in hills, of two stalks, 16 inches the other. It was harrowed on June 8, and cultivated June 11, 18, 25, July 6, 13 and 16.

During this time the following amounts of rain fell: May 29th to June 8th, 1.23 inches; June 8th to 11th, trace; 11th to 18th, .05 inches; 18th to 25th, .76 inches; 25th to July 6th, 3.12 inches; July 6th to 13th, .41 inches. The total rainfall from May 20th to September 1st was 9.11 inches.

The trials were two, both in the same field but one portion manured and the other not, and at the time of cutting the

mean difference was 3.18 per cent. in favor of the cultivation 3 in. deep, but after determining the amount of dry matter there was a difference of only .76 per cent. in favor of the deeper cultivation on the unmanured ground and no difference on the land which was manured; but the mean yield of husked corn stood 1.13 per cent. greater on the shallower than on the deeper cultivation.

In 1892 there were also two trials, one on manured and one on unmanured ground, both in the same field. The corn was planted May 28th in rows 3.5 feet apart and hills twenty-one inches distant the other way, and thinned to two stalks in a hill. The three inch cultivation was with the Deere Eagle Claw and the shallow with the Tower cultivator, the work being done on June 28th, July 5th and 15th. From May 28th it rained more or less every day but six until July 1st, there being only two consecutive days without rain at any time in the interval. The rainfall between planting and June 28th was 9.10 inches, from June 28th to July 5th .51 inches and from the 5th to the 15th .62 inches, while the total rainfall from May 20th until September 1st, was 15.12 inches.

At the time of cutting the corn the total yield on the unmanured land was 3.45 per cent. greater on the shallow cultivation than upon the three inch, while upon the manured land the yield was .58 per cent. in the opposite direction. When the total dry matter is compared the unmanured shallow gave 5.7 per cent. greater yield than the deep, but on the manured the yield was 1.62 per cent. greater on the deep than on the shallow. Comparing the weight of ears the results stand 5.09 per cent. on the unmanured for the shallower and on the manured 1.85 per cent. for the deeper cultivation.

The trials in 1893 at the Station are theee in number, the Deere Eagle Claw and Tower cultivators being used. In trial No. 1, the corn was planted May 27th, 3.5 ft. by 21 in. and two stalks in a hill, and the dates of cultivation for all trials were as follows: Harrowed June 2d and 6th, cultivated June 12th and 13th, 17th and 19th, 23d and 24th, July 1st and 3d and 10th and 11th. The rainfall was as follows:

May 27th to June 6th, 1.68 inches; June 6 to 12th, 2.81 inches; 12th to 17th, 1.5 inches; 17th to 23d, 1.01 inches; 23d to July 1st, trace; July 1st to 10th, 2.7 inches, and July 10th to September 1st, 3.29 inches. While the total rainfall from May 20th to September 1st was 13.61 inches.

In trials No. 2 and No. 3 the corn was drilled in rows 3 ft. 8 in. apart. The differences in the yields for the several trials are 11.41 per cent. for No. 1, 4.46 per cent. for No. 2, and 6.55 per cent. for No. 3 greater on the 3 inch cultivation than on the 1.5 inches. And in the case of the total dry matter the differences stood 4.56 per cent. and 3.46 per cent. respectively for Nos. 2 and 3. The total dry matter was not determined in No. 1, but the yields of kiln-dried shelled corn stood 68.46 bushels for the 3 inch cultivation and 65.45 bushels per acre for the more shallow depth.

The trials in 1894 were five in number, two with a flint corn and three with Pride of the North dent. Two were on sod ground plowed in the spring, the other three on old ground. In the following table are given various facts regarding the several trials:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5
Ground	Old.	Old.	Old.	Sod	Sod
Corn	Dent	Dent	Flint	Dent	Flint
Planted	May 15	May 25	May 17	May 28	May 28
Harrowed	May 25	....	May 20	June 4	June 4
	June 1	....	....	....	....
Cultivated	June 6	June 12	June 12	June 13	June 12
Cultivated	June 15	....	....	....	....
Cultivated	June 21	June 22	June 22	June 23	June 22
Cultivated	June 30	July 2	July 2	July 2	July 2

The rainfall of the season was as follows: May 15 to 20, 1.37 in.; May 20th to 23d, .42 in. No rain from May 24th to June 15th; June 15th to 21st, 1.83 in.; June 21st to 28th, 2.11 in. No rain fell from June 29th to July 13th; July 14th to September 1st, 2.42 in.

The Tower cultivator was used on field No. 4, running it at one inch on one group of rows and as deep as was possible on the other set, but this could not be made to exceep

two inches. On the other fields the Deere Spring tooth, having eight narrow shovels, was used for both depths of cultivation. On these several trials the yield stood as follows:

For green weights.

Field No. 1. Cultivation—3 in. gave 1.41 per cent. more than 1 to 1.5 in.
Field No. 2. Cultivation—3 in. gave 1.09 per cent. less than 1 to 1.5 in.
Field No. 3. Cultivation—3 in. gave 3.15 per cent. less than 1 to 1.5 in.
Field No. 4. Cultivation—3 in. gave 1.01 per cent. less than 1 to 1.5 in.
Field No. 5. Cultivation—3 in. gave same as 1 to 1.5 in.

For dry matter.

Field No. 1. Cultivation—3 in. gave .43 per cent. more than 1-1.5 in.
Field No. 2. Cultivation—3 in. gave 3.43 per cent. more than 1-1.5 in.
Field No. 3. Cultivation—3 in. gave 1.78 per cent. less than 1-1.5 in.
Field No. 4. Cultivation 3 in. gave 3.65 per cent. more than 1-1.5 in.
Field No. 5. Cultivation—3 in. gave 2.98 per cent. less than 1-1.5 in.

EXPERIMENTS IN OTHER PARTS OF THE STATE.

The experiments in other parts of the state have been eight in number, seven in 1894 and one in 1893.

Experiments of Mr. A. F. Noyes.—These were conducted during two years, 1893 and 1894. His first experiment was in a field of Pride of the North dent with rows 98 rods long. Two sets of four rows were cultivated 3 inches deep with four rows shallow between, using a 5-tooth one-horse Rowell cultivator having blades about 3 inches wide, while the middle four rows and the balance of the field were cultivated shallow with the Tower cultivator. I have no record of the time and number of cultivations but all rows received the same treatment except as to depth of stirring the soil. The corn was cut and weighed on the same day, dividing each row into north and south halves, weighing each separately in order that each half might serve as a check upon the other. Numbering the rows from east to west they stand and were cultivated as below:

1.5 in. deep				3 in. deep				1.5 in. deep				3 in. deep			
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

The most equitable comparison which can be made in this case will be to combine 2, 3 with 10, 11 and compare the mean of the four weights with the mean weight of 6, 7; and then to combine 6, 7 with 14, 15 and compare the mean of these four rows with the mean of the two rows 10, 11.

Doing this both with the north and south halves we get the results which are tabulated below:

South half.

No. of row.	Weight.	No. of row.	Weight.
2	1,374 lbs.	6	1,131 lbs.
3	1,390 lbs.	7	1,250 lbs.
10	1,165 lbs.		
11	1,454 lbs.		
Mean	1,345 75 lbs.		1,190.5 lbs.
Difference	155.25 lbs.=13.04 per cent.		

North half.

No. of row.	Weight.	No. of row.	Weight.
2	1,138 lbs.	6	885 lbs.
3	982 lbs.	7	678 lbs.
10	1,095 lbs.		
11	1,070 lbs.		
Mean	1,071.25 lbs.		781.5 lbs.
Difference	298 75 lbs.=37.08 per cent.		

If we combine the weights of rows 6, 7 and 14, 15 and compare their mean sum with that of 10, 11, we have the results below:

South half.

No. of row.	Weight.	No. of row.	Weight.
10	1,165 lbs.	6	1,131 lbs.
11	1,454 lbs.	7	1,250 lbs.
		14	1,386 lbs.
		15	1,298 lbs.
Mean	1,309.5 lbs.		1,266.25 lbs.
Difference	43 25 lbs. = 3.42 per cent.		

North half.

No. of row.	Weight.	No. of row.	Weight.
10	1,095 lbs.	6	885 lbs.
11	1,070 lbs.	7	678 lbs.
		14	1,074 lbs.
		15	1,066 lbs.
Mean	1,082.5 lbs.		925.75 lbs.
Difference	156.75 lbs. = 16.94 per cent.		

In each of these comparisons it is seen that the cultivation 3 in. deep had produced the larger yield. If the total weight of the rows cultivated 3 in. is compared with that cultivated 1.5 in. we shall find the following:

3 inches.	1.5 inches.	Difference.
9,668 lbs	8,768 lbs.	900 lbs.

from which it appears that there is a difference of 10.26 per cent. in favor of three inches as a mean of the whole.

It was observed after the experiment was under way that the northern ends of the two rows 6, 7, fell upon what had some years before been either a gully or a dead furrow and it is this fact which makes the large percentage difference shown in the first comparisons, and this also influences the general average, making it too large.

If we compare the yields from the south half of the field simply we shall have 5,383-5,065= lbs. or a difference of 6.27 per cent in favaor of the cultivation 3 in. deep. If we compare rows 2, 3, with 15, 16, there is in this case a difference of .41 per cent. in favor of the deeper cultivation, or again if we compare 10, 11, with 14, 15, we find still a difference of 9.6 per cent. in the same direction. There appears therefore no escape from the conclusion that whatever may be the reason the rows which were cultivated 3 in. deep produced a larger yield than did those cultivated 1.5 in. deep.

Mr. Noyes' next trial was in a field with rows 80 rods long and, as last year, on a soil of medium clay. This season both the 3 in. and the 1.5 in. cultivation were done with the Rowell 5-tooth one-horse cultivator. An effort was made at the start to make two trials, one exclusively with the Rowell and the other with the tower cultivator, but he found it impossible to work the soil to a depth of 3 in. with the Tower, even when going twice over the ground and the last two cultivations were done with the Rowell. The corn used in these trials was a white dent, and the results are indicated in the table below:

First twelve rows.

	Cultivation 1.5 in. deep.	Cultivation 3 in. deep.	Cultivation 1.5 in. deep.
Weight...	2,126 lbs.	2,242 lbs.	2,194 lbs.

Difference, 82 lbs.=3.8 per cent.

Second twelve rows.

Weight...	1,907 lbs.	2,371 lbs.	2,530 lbs.

Difference, 152 lbs.=6.85 per cent.

Both trials.

	Cultivation 3 in. deep.	Cultivation 1.5 in. deep.
Weight...	2,242 lbs.	2,126 lbs.
Weight...	2,371 lbs.	2,194 lbs.
		1,907 lbs.
		2,530 lbs.
Mean...	2,306.5 lbs.	2,189.25 lbs.

Difference, 117.25=5.35 per cent.

In these two trials it will be seen that there are three pairs of rows 80 rods long cultivated 1.5 in. deep, each of which is lighter than either of the two pairs of rows cultivated 3 in. deep, but there is one pair of rows cultivated 1.5 in. deep which is heavier than either of the two pairs cultivated 3 in. deep.

Experiment of George Wyley.—This trial was made on a soil of black prairie loam having a full foot in depth which is underlaid with a fine textured red clay of great water capacity and having a thickness exceeding two feet on the lower land but upon the higher portions this passes into gravel in the third foot. The rows were planted north and south and were 140 rods long extending across clover sod plowed in the spring, clover sod plowed in the fall, oat stubble fall plowed, and the corn was Murdock's improved dent.

The Tower cultivator was used for the 1.5 inch cultivation and a sulky 4-shovel cultivator with wide pointed teeth was used for the 3 in. cultivation.

The results of this trial are given in the table below:

Clover sod, spring plowed.

CULTIVATION, 1.5 INCHES.		CULTIVATION, 3 INCHES.		CULTIVATION, 1.5 INCHES.	
Total.	Ears.	Total.	Ears.	Total.	Ears.
Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
556	214.4	502	199.2	545	212.4
Clover sod, fall plowed.					
741	294.5	665	212.1	803	243.5
Oat stubble, fall plowed.					
2,424	866 0	2,203	825.8	2,186 1	843.1

In each of these cases it will be seen that there is no instance where the 1.5 in. depth has not produced the larger yield, both of ears and total weight of stalks and ears. In the clover sod, spring plowed, the shallow cultivation is 9.66 per cent. for the total and 7.13 per cent. for the ears larger on the 1.5 inches than on the 3 inches; while for the other two cases the differences stood 16.09 per cent. for total, 26.83 per cent. for ears, and 4.63 for total, and 3.48 per cent. for ears in the second and third respectively.

If the total weights of the rows are compared without regard to the condition of the ground the mean difference gives the 1.5 inch depth an advantage of 7.64 per cent. for the stalks and 8.07 per cent. for the ears over the cultivation 3 in. deep. It should be observed that where the rows passed across the clover sod fall-plowed the ground rose into a gravelly knoll where there was naturally a greater deficiency of water and the effects of the two cultivations are here most marked.

Experiment of E. C. Herrick.—This was on the sandy soil of Portage county and the shallow cultivation was with the Tower, while the 3 in. depth was with a one-horse 5-tooth Planet Jr., and it should be kept in mind that the

last cultivation was on August 13, at which time corn roots were observed to collect upon the teeth of the Planet Jr. cultivator. The rows had a length of 800 feet. Below are the results of the trial:

Cultivation, 3 inches.	Cultivation, 1.5 inches.	Cultivation, 3 inches.
315 lbs.	394 lbs.	319 lbs.
	Difference, 77 lbs. = 24.29 per cent.	

Here it will be seen the results are very pronounced indeed in favor of the shallower cultivation. Only a portion of the corn was husked and in this the ratio of weight of stalks to the weight of the ears was identical in the two cases.

Experiment of Chas. H. Diener.—The cultivation of this trial was done with a one horse five tooth Cribb cultivator having teeth three and four inches wide, and the soil was a sandy loam underlaid at two to three feet with a very fine red clay, having a large water capacity so that here, except in color of surface soil we have conditions very similar to those on the farm of Mr. George Wyley.

The corn rows had a length of fifty-five rods and the results of the trial are given below:

Cultivation, 3 inches.	Cultivation, 1.5 inches.	Cultivation, 3 inches.
1,036 lbs.	971 lbs.	1 008 lbs.
	Difference, 51 lbs. = 5.25 per cent.	

A portion only of the corn was husked and this gave the ears on the cultivation 3 inches deep 45.96 per cent., and on the cultivation 1.5 inches 42.14 per cent. as the ratio of weight of the ears to the weight of the ears and stalks. In this case on a sandy loam the 3-inch cultivation is unquestionably superior in yield to the cultivation 1.5 inches deep.

Experiment of Mr. Herman Kohlwey.—The soil on which this trial was made was a sandy clay containing some gravel and was cultivated with the Ellwood Iron King four-shovel cultivator with teeth 5.5 inches wide. The corn was one of the large varieties and was cut for silage,

the weights being taken at once after cutting, giving the results below:

Cultivation, 3 inches.	Cultivation, 1.5 inches.	Cultivation, 3 inches.
2,244 lbs.	2,154 lbs.	2,250 lbs.

Difference, 93 lbs. = 4.32 per cent.

The rows in this field were 353 feet long and planted in drills 3.5 feet apart.

Experiment of Mr. F. M. Balsley.—This experiment, like the last, was conducted upon a sandy clay soil containing gravel and was worked with one of the Old Gorham four-shovel sulky cultivators having teeth five inches wide. Through a mistake in cutting the corn in this trial, one of the two center rows of the deep cultivation, was put with one of the outside rows of the four on that side, and hence only two rows of the three-inch cultivation remained to be compared with the two of the 1.5 inches. This comparison, however, could be made without violence to the cultivation giving the smaller yield because the slope of the field placed the two rows having the larger yield on the uphill side, which ordinarily would tend to place these at a disadvantage. The results are as follows:

Cultivation, 3 inches.	Cultivation, 1.5 inches
976 lbs.	897 lbs.

Difference, 79 lbs. = 8.81 per cent.

In this case the three-inch cultivation is plainly ahead of the lesser depth, and in the portion of the corn which was husked the ratio of ears to total weight stood 42.94 per cent. for the three inches and 39.88 per cent. for the 1.5 inches.

Experiment of Mr. Grant C. Austin.—This trial was upon a fine black prairie loam and the work was done with a tool very similar to the one used in the last experiment. The rows were 84 rods long planted 3 feet 8 inches apart in drills, and the corn was a white dent. The yields stood as indicated below:

Cultivation, 3 inches.	Cultivation, 1.5 inches.	Cultivation, 3 inches.
2,426 lbs.	2,376 lbs.	2,356 lbs.

Difference, 15 lbs = .63 per cent.

In this case there is practically no difference in the two types of cultivation, there being only .63 per cent. in favor of the 3 inches. None of this corn was husked.

If we bring together the records of the times of cultivation for these seven experiments and the times of planting they stand as below:

Milton.	Fayetteville.	Grafton.	Stephensville.	Plainfield.	Leeds.	Beaver Dam.
			Time of planting.			
May 15	May 14	May 28	May 28	May 24	May 16	May 28
			Time of harrowing.			
May 17, 26	May 26, 31.	June 8, 20	June 2, 6	May 25	May 24, 26.	June 1, 9, 11
	June 1			June 1, 10.		
			Time of cultivating.			
June 2	June 18	June 29	June 21	June 15	June 13	June 19
June 13	June 25	July 6	June 28	June 23	June 26	June 25
June 23	June 29	July 14	July 6	July 2	June 30	July 4
June 28	July 23			July 19	July 9	July 14
				July 21		
				Aug. 2		
				Aug. 13		

Table of rainfall for 1894.

Date.	Milton.	Fay-et'ville.	Graf-ton.	Steph-ensville	Plain-field.	Leeds.	Beaver Dam.	Madi-son.
May 17-18	*	*	......	......	......	2.15	......	1.37
May 20-21	.63	.75	......	......	......	......	......	.24
May 22-23	.50	.13	......	......	......	.43	......	.18
May 26	......	......	......	......	2.25	......	......	......
May 27-30	......	T	T	......	......	......	......	T
June 4	......	......	T	T	......	......	......	......
June 13	......	......	T	......	......	......	......	......
June 15	2.00	.31	.31	.88	.13	......	......	......
June 16-17	5.12	2.25	.63	1.75	2.00	4.19	2.25	1.82
June 18	......	......	.25	......	......	......	.25	.01
June 22	......	......	.38	......	......	......	......	T
June 23-25	.38	.75	.37	.38	.13	2.15	2.88	1.99
June 26-28	......	......	.63	.63	......	.43	......	.08
July 6	......	......	T	T	......	......	......	.04
July 14-16	......	......	......	.20	.12	......	.06	.11
July 18-20	1.50	.75	......	.62	......	.43	25	1.39
July 28	......	......	T	.06	......	......	.33	T
July 31-Aug. 1	......	......	1.38	.12	......	......	......	.27
August 10-12	......	.06	.06	.63	.87	......	.10	.42
August 14	......	.13	......	.06	......	......	......	......
August 20	......	......	.06	......	......	......	......	......
August 26	......	......	......	......	......	.65	......	......
September 3-4	......	......	.12	.50	......	1.30	......	.12
Sums	10.13	5.13	4.19	5.83	5.50	11.73	6.12	8.04

* Heavy rain.

By comparing the table of times of cultivation with that of the times and amounts of rainfall it is not apparent that any relation exists between these and the percentage amounts which the yields show in favor of one or the other depth of cultivation. It is true that at Milton and the Station farm where the last cultivations were the 28th of June or 2nd of July there is the least difference between the yields from the two depths of culture.

EFFECT OF DEPTH OF CULTIVATION ON THE WATER-CONTENT OF THE SOIL.

The effect of depth of cultivation on the soil moisture has been studied during three seasons, the water being determined in one foot sections to a depth of four feet. The samples in all cases have been taken in the center between the two middle rows of each group of four and two adjacent groups of rows only have been compared. Where the slope of the surface was appreciable from one group to another the comparison is made by combining samples from two groups of like cultivation on opposite sides and adjacent to one of the other lying between them.

The table below shows the observed differences at the times there noted:

Table showing the per cent. of water in corn ground cultivated 3 inches and 1.5 inches deep.

	Cultivated.	1 ft.	2 ft.	3 ft.	4 ft.
		Per cent.	Per cent.	Per cent.	Per cent.
Aug. 27, 1892	3 inches	24.09	18.75	18.94	21.18
	1.5 inches	22.85	18.03	17.88	18.97
Difference		1.24	.72	1.06	2.21
Sept. 16, 1892	3 inches	23.14	23.30	21.94	22.46
	1.5 inches	22.70	21.08	19.65	19.58
Difference		.44	2.22	2.29	2.88
No. 2.					
Aug. 19, 1893	3 inches	14.27	15.68	17.17	16.87
	1.5 inches	14.58	15.08	14.92	16.84
Difference		—.31	.60	2.25	.03
No. 3.					
Aug. 19, 1893	3 inches	11.89	12.59	13.63	17.96
	1.5 inches	11.73	12.02	13.92	19.95
Difference		.16	.57	—.29	—1.99
No. 1.					
July 16, 1894	3 inches	11.30	15.57	10.54	11.37
	1.5 inches	9.92	15.43	11.56	13.99
Difference		1.38	.14	—1.02	—1.52

Table showing the per cent. of water in corn ground cultivated 3 *inches and* 1.5 *inches deep*.—Continued.

	Cultivated.	1 ft.	2 ft.	3 ft.	4 ft.
Nos. 2 and 3.					
July 16, 1894	3 inches	13.96	22.74	23.39	19.47
	1.5 inches	12.98	20.44	24.02	21.34
Difference		.98	2.30	—.63	—1.87
No. 4.		Per cent.	Per cent.	Per cent.	Per cent.
July 16, 1893	3 inches	17.63	25 53	25.80	23.18
	1.5 inches	16.34	24.43	24.05	23 20
Difference		1.29	1.10	1 75	— 02
No. 5.					
July 16, 1894	3 inches	11.65	17.47	16.44	13.03
	1.5 inches	10.65	16.85	17.81	13.32
Difference		1.00	.62	—1.37	—.29
No. 1.					
Aug. 15, 1894	3 inches	7.87	11.29	10.60	11.24
	1 5 inches	6.52	9 82	9.24	9.22
Difference		1.35	1.47	1.36	2.02
Nos. 2 and 3.					
Aug. 15, 1894.	3 inches	12.25	16.89	17.50	16 53
	1.5 inches	11.67	16.05	15.85	19.23
Difference		.58	84	1.64	—2.70
No. 4.					
Aug. 15, 1894	3 inches	13.94	18.80	20.06	22.15
	1.5 inches	14 21	18.63	20.24	22.02
Difference		—.27	.17	— 18	.13
No. 5.					
Aug. 15, 1894	3 inches	8.13	12.49	13.97	17.04
	1.5 inches	7.13	11.26	12.75	11.79
Difference		1.00	1.23	1.22	5.25

These tables show in a very conclusive manner, covering as they do three consecutive years and being made up of twelve sets of determinations, each extending to a depth of four feet, taken in seven different fields, that cultivation

3 inches deep does leave the gound more moist below the soil stirred than does the cultivation 1.5 inches deep. Indeed it will be seen that there are only two cases in the surface foot and none in the second foot where the soil of the 3 inch cultivation is not more moist than the shallower depth, the average difference being .74 per cent for the first foot and 1.00 por cent. for the second foot and this means for the soils in question a difference of 1.5 lbs. of water to the square foot in the upper two feet in favor of the 3 inch cultivation; and this difference has occurred, too, where, in the majority of cases, there has been a larger production of dry matter and presumably a larger consumption of water.

The data of the table above bring into strong relief another effect which has been referred to in earlier reports, namely that of translocation of soil moisture. Referring to the table it will be seen that of the four sets of samples taken on July 16, 1894, from as many different fields, there is only one exception to the rule that while the surface two feet of the 3 inch cultivation is more moist than the 1.5 inch cultivation the reverse of this is true of the third and fourth feet, these being dryer. The facts appear to be that while the surface two feet of soil are more moist they are drawing water faster from the third and fourth feet than they could were they dryer.

If we bring together all of the cultivation experiments conducted by this Station, placing the differences in favor of the 3 inch cultivation in one group and those in favor of the 1.5 inch in another they will stand as given below:

Table showing the percentage difference in yield between cultivation 3 inches deep and 1.5 inches deep.

	3 inch cultivation.	1.5 inch cultivation.		3 inch cultivation.	1.5 inch cultivation.
Experiment Sta.:	per cent.	per cent.	*Experiment Sta.:*	per cent.	per cent.
No. 1, 1891........	.76	....	No. 4, 1894	3.65	....
No. 2, 1891........	.00	.00	No. 5, 1894..........	....	2.98
No. 1, 1892.	....	5.70	Milton.............	.63	....
No. 2, 1892.........	1.62	....	Fayetteville..........	8 81	....
No. 1, 1893.........	3.46	....	Grafton..............	4.32	....
No. 2, 1893.........	4.56	....	Stephensville........	5.25	....
No. 3, 1893.......	11.41	....	Plainfield...........	....	24.29
No. 1, 1894.......	.43	....	Leeds................	....	7.64
No. 2, 1894.........	3.43	....	Beaver Dam, 1893.....	10.26	....
No. 3, 1894.........	....	1.78	Beaver Dam, 1894.....	5.35	....

It is here seen that of the 20 trials 14 are in favor of the 3 inch cultivation and 5 in favor of the 1.5 inches, while in the other the yields are equal.

These results are not in full accord with work done at some other stations, but it should be said that this could not be expected in all cases. The Illinois experiments which have extended over 6 years give an average of 3.27 per cent in favor of 1.5 inches as compared with a depth which Prof. Morrow states ranges from 4 to 6 inches, the latter being exceptional, and yet two of the six years' trials gave yields of 14.27 per cent and 8.56 per cent respectively in favor of the deeper cultivation.

Those of the Kansas trials which are comparable in depth with our own, three in number, stand two to one in favor of 3 inch, with a mean difference of 2.18 per cent. The Indiana trials also comparable in depth and covering six years stand one to five in favor of one inch as against three inches with a mean difference of 4.78 per cent. Ohio comparing more than four inches with two inches finds 1.97 per cent. in favor of 2 inches. Utah comparing 3 inches with 1 inch finds a balance of 7.75 per cent in favor of 1

inch, and Missouri comparing 5 to 6 inches with 1 inch finds a balance of 25.07 per cent. for ears and 21.17 per cent. for stalks in favor of the less depth. Other stations have also done work which favor the shallower depths of cultivation, but just what the depths are is not stated.

It seems to be quite definitely settled that with rare exceptions a cultivation as deep as four inches is less productive than a shallower one. It seems also clear that the best depth to cultivate is not constant either for soil or seasons. The problem is manifestly a complex one and in view of the magnitude of the interests involved merits a more extended and careful study than it has yet received.

EFFECT OF DEEP AND SHALLOW CULTIVATION ON SOIL TEMPERATURE.

During the study of the present season soil temperatures in all of the fields under experiment have been taken to depths of 3 feet and with wholly concordant results, showing the soil cultivated 1.5 inches deep warmer than that cultivated 3 inches deep, but with differences less than those recorded for last season, the mean difference of all measurements being as below.

1st foot.	2nd foot.	3rd foot.
.82° F.	.59° F.	.36° F.

The observations this season were made in the same manner as described in the last report, p. 190 except that two thermometers were used and readings taken simultaneously on both types of cultivation. The thermometer used is represented in Fig. 26.

The diurnal changes of temperature at a depth of one foot were also studied with the aid of two self-recording thermometers similar in pattern to that described in the Ninth Annual Report, p. 203, one of these instruments being set in the middle pair of two adjacent groups of four rows, one of which was being cultivated 3 inches and the other 1.5 inches deep. The mean daily changes during the week

ending July 26 was for the 1.5 inch depth 1.65° F, and for the 3 inch depth 1.45° F., making a difference in diurnal range of .2° F.

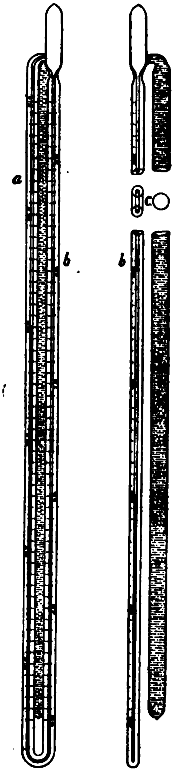

FIG. 26.— Showing maximum and minimum soil thermometer graduated to tenths of a degree F. and the bulb one foot long, giving the mean temperature of the foot of soil in which it is placed.

These instruments were carefully calibrated at the close of the trial, which extended over four weeks, by placing them side by side in a reservoir of water and measuring the temperature of the water in contact with the bulbs by means of three mercurial thermometers graduated to tenths F°, readings being taken every 15 minutes at each end and in the center during a period of four hours.

THE RATE OF PERCOLATION FROM LONG COLUMNS OF SOIL.

F. H. KING.

The experiment described in the last Annual Report, page 175, has been repeated the present year using apparatus represented in Fig. 27, where each tube is 8 feet long and 5 inches in diameter and constructed as described under the figure. These were all filled with water-free sand having five degrees of fineness, namely, that which passed a screen of 20 meshes to the inch but was retained by one of 40, that which passed a screen of 40 but was retained by one of 60,

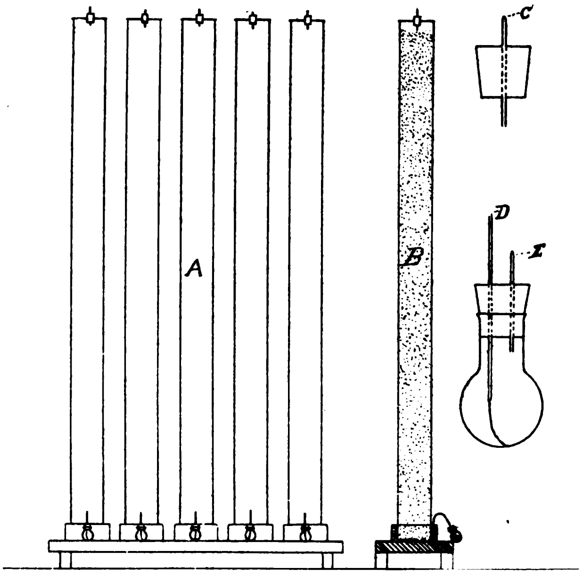

FIG. 27.—Showing apparatus for studying percolation from long columns of soil. A, prospective, and B, sectional views. C, rubber cork with glass tube drawn to a nearly closed point. D, discharge tube, and E, tube to equalize pressure. The base of each tube has a water receptacle into which the water percolates through notches cut in the lower edge of the soil tube.

that which passed one of 60 but was retained by one of 80, that which passed one of 80 but was retained by one of 100, and last, that which passed a screen of 100 meshes.

Each cylinder was filled with water from below until it overflowed at the top and the percolation started January 30. In the table below is given the amount of water which percolated during the times there stated, and also the per cent. figured on the dry weight of the sand.

Table showing the amount and per cent. of water which percolated from columns of sand 8 feet long.

TIME.	No. 20.		No. 40.		No. 60.		No. 80.		No. 100.	
	Gms	Per cent.	Gms.	Per cent.	Gms.	Per cent.	Gms.	Per cent.	Gms.	Per cent.
30 min	3298.3	6.59	2427.1	4.95	1730.0	3.57	486.0	.999	390.0	.791
30 min	1506.5	3.01	1687.5	3.44	1451.9	3.00	416.7	.856	278.2	.564
1 hr., 7 min	718.7	1.43	837.3	1.71	531.2	1.10	551.0	1.132	330.7	.670
1 hr., 32 min	486.8	.97	478.3	.97	763.4	1.57	541.7	1.113	353.7	.717
1 hr., 34 min	229.3	.46	239.6	.59	376.2	.78	476.7	.980	305.2	.619
2 hr., 33 min	193.7	.39	212.3	.43	249.0	.51	507.3	1.043	375.8	.762
15 hr., 0 min	463.3	.93	489.1	1.00	579.0	1.19	944.3	1.945	1103.3	2.033
23 hr., 0 min	250.8	.50	211.0	.40	217.9	.45	410.2	.843	499.4	1.012
24 hr., 0 min	85.0	.17	94.6	.19	122.7	.26	184.5	.379	161.0	.326
24 hr., 9 min	68.8	.14	78.3	.016	46.9	.10	99.3	.204	149.8	.304
24 hr., 5 min	66.8	.13	23.5	.05	33.8	.07	49.7	.102	59.0	.120
23 hr., 35 min	27.0	.05	26.1	.033	1.9	.004	26.8	.055	38.6	.075
49 hr., 55 min	10.92	.22	188.0	.38	129.5	.27	179.3	.369	209.3	042

At the end of this time the several soils had lost during the nine days of percolation the following totals:

	No. 20.	No. 40.	No. 60.	No. 80.	No. 100.
	Gms.	Gms.	Gms.	Gms.	Gms.
Dry weight of sand	50050.0	49060.0	48490.0	48650.0	49340.
Weight of water	7499.2	7042.7	6234.4	4873.5	4154.
Per cent. of water	15.29	14.35	12.86	10.02	8.42

The rate of percolation it will be seen decreased in a very marked manner as the soil grains became more and more

fine and that the finest sand had lost in the time only a little more than one-half the amount of water which the coarsest one had.

Table showing the amount and dates of percolation of water from sand of five degrees of fineness and columns 8 feet long.

	No. 20.	No. 40.	No. 60	No. 80.	No. 100.
	Gms.	Gms.	Gms.	Gms.	Gms.
February 7	.6	.8	18.1	20.5	21.5
February 8	.0	.0	11.2	12.4	.0
February 9	19.2	24 3	.0	22.7	20.1
February 12	1.1	14.8	28 2	8.5	23.2
February 13	.0	14 8	7.8	17.3	27.1
February 14	11.3	8.4	19.1	8.7	12.7
February 17	7.5	1.2	9.7	1.0	5.0
February 19	10.2	1.3	37.3	19.9	13.8
February 20	.0	.0	.0	45.0	15 7
February 20, P. M	40.7	57.3	.0	.0	32.9
February 21	.0	.0	16.8	.0	.0
February 23	.0	.0	.0	43 5	17.8
February 26	44.7	1.8	47.0	35 9	45.5
February 27, A. M.	.0	.0	.0	20.2	.0
February 27, P. M	.0	48.5	.0	.0	16.3
February 28	.0	.0	72.8	.0	11.7
March 4	51 3	.0	.0	.0	.0
March 12	.0	.0	.0	12.5	.0
March 18	42.0	38.0	.0	.0	31.5
March 22	.0	.0	.0	3.0	7.3
April 16	48.0	40.8	.0	7.0	.0
April 17	.0	.0	.0	7.9	.0
April 19	.0	.0	52.5	35.2	.0
May 10	42.7	.0	.0	.0	25.3
May 15.	.0	33.8	.0	6.5	.0
May 17.	46.9	.0	.0	18.2	41 0
June 12	57.5	40.0	55.3	25.9	28.1
June 13	.0	.0	.0	15.8	.0
July 13	2.0	37.9	2.5	31 6	43.0
July 29	44.6	.0	1.5	6.9	.0
August 8	.0	35.3	.0	15.0	.0
October 3	.0	48.3	.0	.0	.0
October 24	69.7	.0	.0	.0	.0

But the most remarkable feature of this experiment is the very long period during which the percolation continued and not much less surprising is the irregularity with which it occurred. It will be seen from the table above that all of the samples discharged some water as late as July 13, after the lapse of 164 days; while cylinder No. 20 discharged 69.7 grams of water on October 24, after a lapse of nearly nine months.

If we compare the total percolation from February 7 to Oct. 24 in the several cases, we have the results stated below:

	No. 20	No. 40.	No. 60.	No. 80.	No. 100.
	gms.	gms.	gms.	gms.	gms.
Dry weight of sand	50050	49060	48490	48650	49340
Weight of water	540	452.3	374.8	441.1	440 0
Per cent. of water	1.079	.916	.773	.907	.892

Here it is seen that after the first rapid percolation had taken place all samples of soil went on drying at nearly equal rates, each loosing not quite one per cent. of its dry weight, except the coarsest sand which continued to percolate not only longest but also lost the largest amount of water during the latter interval as it did during the first.

This observed slow percolation which passed out of the 8-foot columns of sand, and hence under field conditions beyond root action, represents the following loss when figured in pounds for columns one sq. ft. in section

No. 20.	No. 40.	No. 60.	No. 80.	No. 100.
9.15 lbs.	7.77 lbs.	6.56 lbs.	7.69 lbs.	7.56 lbs.

and these losses represent more than an inch of rain in every case.

Irrigation of sandy lands.— These observations have a very important bearing upon the irrigation of sandy lands and show in an emphatic manner that it would be extremely wasteful not only of water but also of fertility to apply water in large quantities at a time unless these lands are underlaid at a shallow depth with a much more impervious layer. We have in our state large areas of these lands lying close to water, and these facts will be helpful to those who are now thinking of improving such lands by irrigation.

SMALL LATERAL PRESSURE OF SILAGE AFTER SETTLING HAS CEASED.

F. H. KING.

We have now two cases where silos have burned after being filled with silage, one owned by Mr. C. E. King of Whitewater and the other by Mr. A. D. Rice of Milton. The fact that the silage in both these cases stood up, retaining the form of the space in which it was stored, demonstrates that after silage has once settled in a silo the lateral pressure then becomes very small or entirely ceases. Fig. 28 is a photo-engraving of the silage from Mr. Rice's silo as it stood October 20, a few days after the fire. The silo was round and when it burned as the result of a fire starting in the hay of the barn the silage was not appreciably impaired, the surface being so green and damp that it hardly charred enough to leave the surface black.

The silo of Mr. King was rectangular and in his barn, which burned four days after the completion of filling, but it should be said that the filling extended over a considerable period of time. This fact of the rapid dying away of the lateral pressure has an important bearing on the construction of silo walls and shows that unless the walls are very rigid, so as not to spring when the silage settles, air spaces will be left between the walls and the silage in the upper part of the silo which must result in a large loss of dry matter.

FIG. 28.—Showing silage from Mr. Rice's silo as it stood a few days after the fire.

SCALES USED FOR HEAVY WEIGHING.

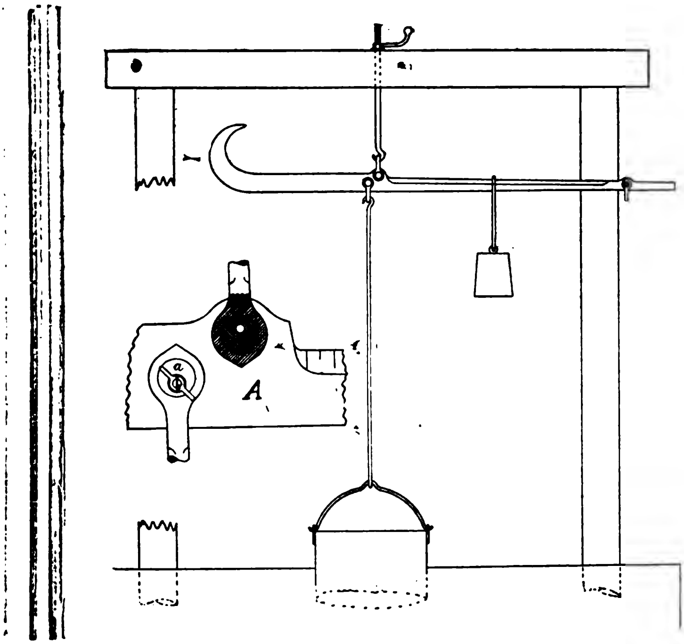

FIG. 29.

The scales which have been used in weighing the large cylinders of soil in the pot experiments described in this and preceding annual reports are represented in Fig. 29. It is a specially constructed weigh-master's beam, having a capacity of 1,000 lbs., and turns quickly with less than one-tenth of a pound when carrying a weight of 600 lbs. The beam is graduated to tenths of a pound by notches in which a movable poise may be placed, giving a maximum weight of 50 lbs. Higher weights are measured with the aid of a set of fixed weights which hang from the knife-edge shown at the right end of the beam.

The several knife-edges are protected with removable guards shown at A. These are held in place, when the scales are not in use, by set screws.

DESTRUCTIVE EFFECTS OF WINDS ON SANDY SOILS AND LIGHT SANDY LOAMS, WITH METHODS OF PREVENTION.

F. H. KING.

There is a rudely crescent shaped tract of land lying a little to the south of the center of this state and extending from Weyauwega, Berlin and Portage on the east to Barron, Menononie and Pepin on the west, which is covered, over most of its area, outside of the swampy and marshy districts, with a light sandy soil or sandy loam.

Practical experience has now abundantly proved, both on the southeastern and northwestern ends of this crescent that its soils are capable, when rightly managed, of producing large quantities of potatoes of very excellent quality. This crescent has a mean width of not less than 40 and a length of fully 180 miles; and besides this tract there are three other isolated areas of considerable magnitude of the same general nature in the northern part of the state, and to which the remarks of this paper will apply when these lands are brought under cultivation. There are also very many much smaller and more isolated but widely scattered areas which are in a degree subject to the same conditions, but being surrounded by heavier soils and ranker growths of vegetation their fields are less injured during dry windy times than are those of the larger tracts referred to.

OBSERVATIONS ON THE DESTRUCTIVE EFFECTS OF WINDS ON THE LIGHTER POTATO SOILS OF WAUPACA, PORTAGE AND WAUSHARA COUNTIES.

On the seventh of May the writer had occasion to go to Plainfield to make preparations for an experiment on the in-

fluence of deep and shallow cultivation on corn. There had been what was described as a very heavy fall of rain on the 5th and 6th, but on the 7th it was clear and cold and the wind was blowing strong from the northwest. During this and the following day, in spite of the preceding heavy rain, the fields about Plainfield, and Almond in the adjoining county, drifted very badly. On the morning of the 8th the drifting had gone so far that on many fields at both places the loose soil with which oats were covered, whether with seeder or with drill, had been driven from the fields to such an extent as to leave the kernels of grain entirely exposed, the plants lying flat upon the ground hanging by a few roots and whipping in the wind.

On many other fields, where the drifting had not been so bad, the oats, which at the time were about 3 inches high, had been cured like hay down close to the ground, and even the leaves of the dock sorrel which chanced to be growing with the oats were blackened and so dry as to crumble in the hand. Very many of the blades of oats were broken squarely across close to the ground and presented an appearance which suggested to the farmers the idea that they had been cut off by the drifting sand. The blades were not, however, cut entirely off, but rather they were so badly broken as to bend at a sharp angle at the injured place, allowing the blade to lie flat upon the ground. It was also observed during this first visit that wherever a field lay to the leeward of any sort of shelter the bad effects of the wind were either not apparent or else they were very much reduced; and, in view of the fact that a general effort is at present being made to clear out all trees and especially groves so as to produce large open fields, it seemed advisable to make a careful study of the influence shelters of various sorts had exerted upon the fields during the winds of the present season, and so, under Prof. Henry's direction, the work was taken up at Plainfield on May 29th and four days given to a careful study of the existing field conditions for a radius of 3 miles about this place and about Almond in Portage county.

The observed facts are here briefly recorded, mainly in the order they were noted, to show the extent of injury which did result from winds under the present system, and to show what improvement may be hoped for under the system to be proposed.

1. A field of clover, seeded last year, shows a much thicker stand and better growth on the east side of a board fence for a distance varying from 20 to 40 feet.

2. On a field of hilly ground sowed to oats in drills north and south, the hollows and hill sides have suffered much less than the summits, and the eastern slopes are in far better condition than the western and southwestern sides.

3. Lying to the eastward of a field of clover, seeded last year, is a piece of oats seeded to clover, and here the catch is very much better close to the grass, and is evidently so as far out in the field as two rods.

4. A north and south road fenced with wire and two rods wide has scattering trees from ten to eighteen feet high together with a scanty growth of hazel on both sides. To the east of this is a field of oats badly damaged by the winds at a distance from the shelter, but a strip two rods wide adjoining that seems wholly to have escaped injury.

5. From a field of oats to the west of the last the sand has drifted into the road until it has a mean depth of perhaps twelve to eighteen inches and in places it is fully thirty inches deep. Sand has even stopped out in the field to the westward for a distance of ten to twenty feet so as to entirely bury the grain, and this too is a coarse sand which the wind has rolled along the surface after carrying away all of the finer and more essential portion.

6. The western field referred to in 5 lies to the east of a piece of timothy in which there is a large growth of dock sorrel and along the whole western side of this oat field for a distance of fully 200 feet there is a good stand, while the eastern half, thirty rods in width, is almost wholly blown away. It should be said, however, in this connection that the ground rises eastward and that the character of the soil changes somewhat, and to these facts a part of the strong contrast is due.

7. In the grass field referred to in 6 the stand is very much better and the growth more rank on a strip 20 feet wide on the north side of a rail fence than it is farther away, and the same thing is true on the east side of another rail fence, though the contrast is not as marked.

8. Another field of oats, having grass to north and west of it, has a strip of apparently uninjured grain 100 feet wide adjoining the grass, and in the northwest corner the protected area has a width of fully 200 feet as shown in Fig. 29. Figs. 30 and 31 show the condition of the ground on July 17th.

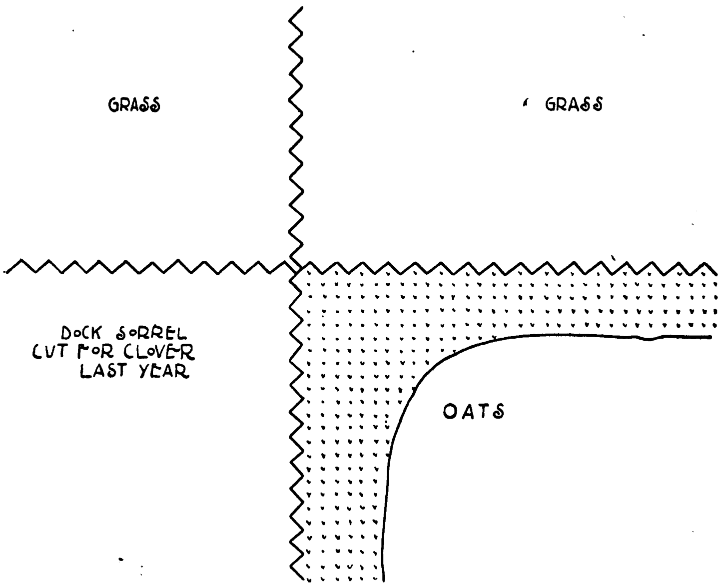

FIG. 30.—Showing protected area 100 feet wide to the east and 75 ft. wide to the south of grass fields and rail fences.

9. A field of oats lying to the northwest of the last has been so thoroughly ruined by the wind that fully five-eighths of it has been harrowed over again to fit it for potatoes, but along the south margin of the field, for a distance of 150 feet from a rail fence, the stand of oats is very good and they have not been disturbed, and on this strip the oats improve in quality the closer the fence is approached.

FIG. 31.— Showing condition of oats on the protected area of fig. 30 July 17. View taken 75 feet east of the north-and-south fence.

FIG. 32.— Showing condition of oats on unprotected area of fig. 30 July 17. View taken 200 feet east of fig. 31.

There was a piece of grass on the west of this field at the time of the wind, but which has now been plowed, and along the margin of the grass, for a distance of 200 feet, the quality and stand of oats is much better than farther away; and the same fact is observed regarding another field of oats lying to the east of a close fed level pasture free from trees and shrubs.

10. On May 20th I examined the country to the southeast, south and west of Plainfield, and in the first field of oats, which had a piece of clover and timothy against it on the west, and a field of woods 60 rods still farther to the west, the catch of clover is excellent on a belt 200 feet wide along the grass, but farther to the east there is scarcely a clover plant to be seen and the oats here are very much injured. It should be noted, however, that this field rises gently toward the east along its northern half where the oats are most injured, and this difference in topography is probably in part the cause of the greater destruction there. The southern half of this field of oats is on new ground against which, on the south, there is a heavy growth of trees in a wide grove, and here there is a fair stand of clover throughout, but the catch is better on the west side, and, yet on this section the ground does not rise toward the east as in the case to the northward.

11. A level field seeded to clover and timothy last year is bounded on the north by a road and a strip of woods. Here the clover has a much thicker stand and ranker growth in a belt along the north side than it has to the southward.

12. I notice everywhere that even small differences in topography exert a marked influence on the stand and growth of clover, which is one or two years old, the clover being best in the depressions and poorest on the higher ground even when the difference in level may not be greater than two or three feet.

13. The southern half of field 11 has been plowed this spring because there was so poor a stand of clover upon it, but across the east end, adjoining a strip of grass and hazel the clover is good for a width of twenty feet, and this portion has been allowed to stand.

14. Another piece of seeding now two years old and which was cut last year for clover seed has a width north and south of thirty rods and a length four times as great. Lying to the north of this field is a piece of wild land which has been covered with small scattering trees, but which the present year has been plowed. The grass field in question slopes gradually southward and in a strip along the northern margin from 120 to 180 feet wide, there is now a fair stand of clover, while to the southward only timothy is to be seen except in the slight hollows which occur here and there.

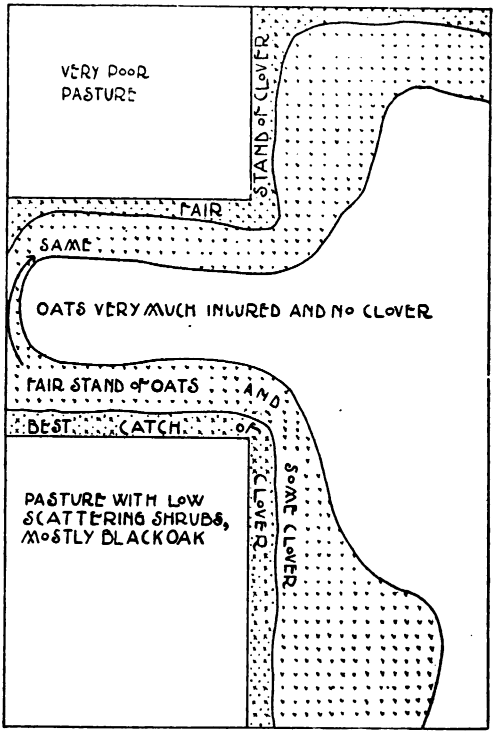

FIG. 33.— Showing the protected areas as described in paragraph 15.

The western end of this field has a strip of unbroken land joining it but upon which there are no trees; here a stand of clover nearly as good as that noted on the north side, stretches entirely across the piece and having a width of perhaps 75 feet.

15. I come next upon a field of oats, sowed with a drill

and seeded to clover, which has the form and surroundings indicated in Fig. 33. The greatest length of this field from east to west is about 80 rods and from north to south 120 rods. The margin in which the clover has not suffered seriously is about two to six rods wide and has the greatest width where in the figure the designation is "best catch of clover."

16. I cross now the nearly level and unreclaimed lands to the southeast of Plainfield on which there is at present only a scanty growth of small oaks with insufficient grass to cover the soil. On this tract plans are being made to clear large fields for potato culture.

17. A field in this tract, 600 feet wide from north to south and 800 feet long has been cleared and sowed to spring wheat, but it has drifted so badly that on the eastern margin are to be seen sand drifts ten to twelve inches deep, and this, too, when surrounded on all sides by unreclaimed lands.

The west and north margins of this field had received a considerable protection from the unreclaimed land as will be seen from an inspection of Fig. 34.

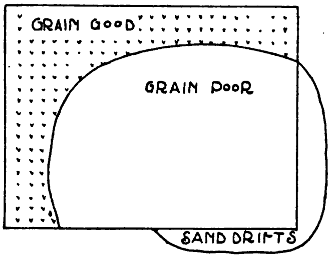

FIG. 34.—Showing the effect of protection referred to in paragraph 17.

18. Passing now to the southwest of Plainfield I come upon a field of oats seeded to clover, which is 80 rods long by 30 rods wide, and having the railroad on its east and a wagon road fenced with wire on the west. To the north of the east end of this field is another, also sowed to oats, bu of earlier seeding. Other surroundings of this field are indicated in Fig. 35. On the unshaded section the oats are practically all gone from both the earlier and later seeding, and on the light shaded section not more than 60 per cent.

of the oats are left and the clover is all gone. But on the heavy shaded area along the road and adjacent to the piece of sod, which was plowed after the worst wind, the oats are good and there is a fair catch of clover.

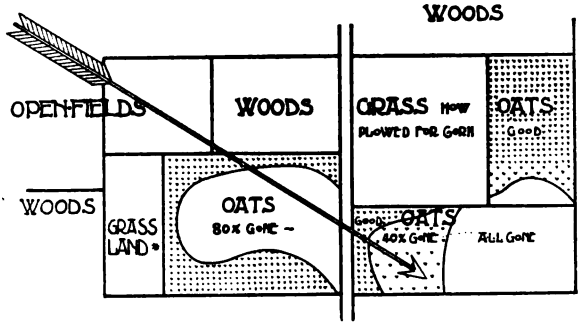

FIG. 35.—Showing the two fields and surroundings referred to in paragraphs 18 and 19. The arrow indicates the direction of the wind.

Along the railroad the sand has drifted upon the track 12 inches deep, and along the wire fence which makes the southern boundary of the field, the sand has drifted until it makes a high ridge along the unshaded area, and this has the appearance of having been formed, in part at least, some time earlier than this spring.

19. Another field lying to the west of the last has been so badly drifted that certainly less than 20 per cent. of the oats are left standing on the unshaded area, Fig. 35. This piece too shows evidence of having drifted badly under a southwest wind in earlier years, for all along the margin of the woods designated in the figure the sand has drifted high along the fence and the drifts extend fully 12 feet into the woods. Beyond this piece of oats very level unbroken fields stretch away to the southwest for a distance of more than one and a half miles.

20. Lying still to the southwest of the last field is a 40 acre piece of oats over large portions of which from two to three inches of soil must have been completely swept away, so that these areas now have the appearance of being covered with a coarse sand and gravel soil. Pushing the surface sand away you come upon the usual sandy loam of the locality, and this makes it evident that the surface dressing of sand and gravel now to be seen is composed of

the coarse grains which are mingled with the ordinary soil, but which are left behind as the winds bear the finer grains away.

This field has a piece of woods lying on its northern side, and south of this shelter for a distance of 150 feet there has been this year no drifting.

21. A field of oats lying east of a field of corn stubble, unplowed, appears to have received much protection from it for the whole eastern half of the field is swept away while the western half still has a fair stand of grain, and this is better the nearer you approach the corn stubble. Portions of the corn stubble are thickly overgrown with dock sorrel, and to the leeward of these portions the oats are best.

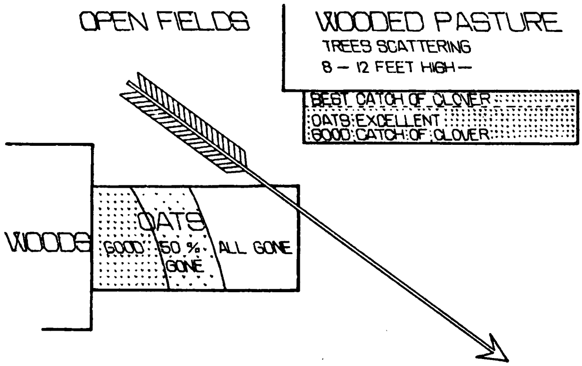

FIG. 36.—Showing the protection afforded by groves referred to in paragraphs 21 and 25. The arrow indicates the direction of the winds.

22. Two other fields lying, one east of corn stubble and the other east of oat stubble overgrown with sorrel, have each good stands of oats on their western halves while on the eastern halves the oats are all gone so that the ground is now bare.

23. A field of winter rye now headed out and lying to the south of a piece of woods has a much thicker stand and better growth in a strip 30 feet wide along the margin of the woods. Here the rye is 6 to 8 inches higher than it is on other portions of the field.

24. Coming next to a field of oats some 60 rods from east to west and 30 rods north to south, lying east of a piece of woods, we find its whole eastern two-thirds so completely

FIG. 37.— Showing sand drifted from a field of grain.

FIG. 38.— Showing the grove influencing the rate of evaporation recorded on page 310.

FIG. 39.—Showing a dust cloud over a corn field June 1, 1894. The foreground shows a field of oats destroyed by earlier winds.

FIG. 40.—Looking east across the cornfield of fig. 39, between gusts of wind.

FIG. 41.— Showing the nature of the surface of the drifting cornfield of figs. 39 and 40.

FIG. 42.— Showing the nature of the surface of a field adjoining the drifting cornfield, which was not drifting.

ruined that it is scarcely more than a naked field while the western third is fresh and green.

25. Another piece of oats seeded to clover and lying on the south side of a wooded pasture has a length of 80 rods from east to west, but a width of only 15 rods; this field is fresh and green throughout its whole extent and has a good catch of clover but the catch is best and thickest in a strip three rods wide along the wooded pasture. This field is related to the last as indicated in Fig. 35, the two corners being not more than 10 rods apart, and both the topography and soil identical so far as the eye can see.

26. An 80 acre field with its long axis north and south, lying west of Plainfield, has suffered worse than any yet visited. The southern two-fifths of this field had been sowed to oats and seeded to clover and the northern two-fifths had been seeded to clover alone; between these two fields was a piece of seeding of three years' standing which was being plowed for potatoes. The only green thing left on the two portions of this field was a small patch of oats sheltered by the farm buildings and a field of grass back of them, which together occupied the southwest corner of the eighty. A lane about two rods wide fenced with two boards below and wire above and lying along the east side of the field is drifted full of sand to the level of the top of the boards. The exceptional force of the wind here is due to the fact that a wide stretch of level, open and treeless fields extends for a long distance to the westward.

27. Another field lying to the east of the last and longest from east to west is entirely swept clear of its crop of oats except on its western end where it was slightly sheltered by the fences of a narrow lane, and two other fields, lying still farther to the east, have been similarly devastated, each having grain remaining only on the western end. Fig 36 is a photo engraving showing sand drifts formed in this locality.

28. Passing now to Long Prairie in the vicinity of Almond, Portage county, it may be said in general for thi section that while the effects of the wind have not been as

bad as they have been about Plainfield yet here, even on the fields having the best soils in the best condition, the destructive effects are very evident and especially upon the seedings of clover.

In a 40-acre field bounded on the north by 40 acres of woods a strip 100 feet wide of second or third year seeding to timothy and clover has been held in grass, while the rest of the field is sowed to oats and wheat mixed. On this strip of grass all the clover has been killed out except in a belt 35 feet wide close to the woods, showing that in some manner, here as well as at Plainfield, the shelter of the woods has a marked influence upon clover. Out in the field the grain has been much injured by the winds, the eastern half of the field being damaged much more than the western half.

29. In another field lying east of one not plowed at the time of the wind and which has a board fence on its west there is a very marked difference in the stand of both oats and clover to which the piece was seeded. Certainly not more than 50 per cent. of the oats remain on the eastern two-thirds and almost no clover, while on the western third the stand grows gradually better as you near the fence where both are in good condition.

30. In another field seeded last year to clover and at the present time in pasture the stand of clover is much better in a strip along the fences on all sides; and in an adjoining field seeded two years ago to clover, lying east of a road, fenced on both sides with boards, the clover is all gone except in a strip two rods wide along the road. Still another field, joining the last on the north and lying east of a three board fence, has no clover except in a belt from 16 to 20 feet wide along this fence.

31. The next three fields visited were sowed to oats and seeded to clover and each field was bordered on the west by pieces of grass. The soil in each of these fields is hevier than usual, slightly lumpy and the drifting had not been enough to cover up the drill marks which extended north and south. On these three fields I counted the number of young clover plants on equal areas at different distances

from the grass lands with the results given in the tables below. The seeding of the first two fields was light and the last very heavy. The method of counting was to measure off 20 paces and then count the number of clover plants between three drill rows in that space for the two pieces of lighter seeding and between two drill rows on the piece of heavier seeding.

Table showing the catch of clover at varying distances to the eastward of grass land.

Field No. 1.

	At 50 feet.	At 200 feet.	At 400 feet.
First count	187 plants.	120 plants.	88 plants.
Second count	209 plants.	139 plants.	75 plants.
Third count	187 plants.	131 plants.	68 plants.
Total	574 plants.	390 plants.	231 plants.

Field No. 2.

	100 feet.	200 feet.	400 feet.	600 feet.	800 feet.	1,000 feet.
First count	77 plants.	55 plants.	43 plants	67 plants.	51 plants.	27 plants.
Second count	73 plants.	109 plants.	78 plants.	66 plants	54 plants.	11 plants.
Third count	99 plants.	113 plants.	72 plants.	56 plants	30 plants.	10 plants.
Total	249 plants.	277 plants.	193 plants.	189 plants	138 plants.	48 plants.

Field No. 3.

	50 feet.	400 feet.	700 feet.
First count	377 plants.	166 plants.	203 plants.
Second count	382 plants.	209 plants.	180 plants.
Third count	371 plants.	225 plants.	160 plants.
Total	1130 plants.	600 plants.	543 plants.

These figures appear to show that the catch of clover tends geneally to decrease as you progress eastward across the fields and that it is best on the western margin nearest to the grass. When it is borne in mind that these fields had not drifted, the natural inference is, that the diminishing

stand of clover as you pass eastward across the fields must have been due to an increasing drying action of the winds which caused most of the plants to wither, and these specific observations are in harmony with most of the facts recorded regarding the preservation and destruction of fields of grain.

32. The next field visited lies to the north of an east and west belt of trees a mile or more in length, from eight to fifteen rods wide and in which the trees attain a heighth of thirty to fifty feet. It is on the south side of this wind break at a distance of forty rods that field No. 3, just referred to, lies, and to it, in my judgment, the very excellent stand of clover there noted is partly due. The field now entered has a width of sixty rods from east to west; and while there is a thick stand of clover in the oats for a distance of three rods to the east of a slight hazel hedge along the fence, beyond this there is scarcely a plant to be seen. This field slopes very gently to the northward, and as the northern margin of the field is approached more clover plants are seen and the stand becomes fair again along the north side.

33. To the northeast of the last is a very large field sowed to oats, broadcast. and seeded to clover. Here the catch of clover over the whole field is very poor, but there can be no question about the stand being better near the east margin of grass fields and along both the east and south sides of fences even when these are wire and have only a narrow strip of blue grass along them. In the northwest corner of this field is a piece of old seeding in which the only clover to be seen is found in a strip two rods wide along the fences.

34. In a field to the west of this last is a similar piece of old seeding in which all grasses are better along the fences on the north, west and south, and the only clover plants to be seen are in a marginal strip from 4 to 6 rods wide along these fences, and the same remarks apply to still another field where a belt of clover is to be seen on the south and east sides of two fences.

35. Traveling westward across a field of old seeding, 60

to 80 rods wide, not a single stool of clover is seen until within 12 rods of the western side where there is a fence composed of two boards at the bottom and three wires above, and here there is a stool of clover on the average every 10 feet square.

INFLUENCE OF WOODS, GRASS-FIELDS AND HEDGE-ROWS ON THE RATE OF EVAPORATION AND AMOUNT OF MOISTURE IN THE AIR OVER FIELDS TO THE LEEWARD OF THEM.

An effort was made, by direct experiment, to measure the influence of woods, grass fields and hedge rows on the rate of evaporation at different distances to the leeward of them on clear bright days.

Influence of woods on the rate of evaporation to the leeward.— To study the rate of evaporation at different distances from groves, six evaporometers were used made after the plan of the Piche evaporometer but with the evaporating surface much larger while the graduated tubes were the same size, the object being to make the instruments more sensitive.

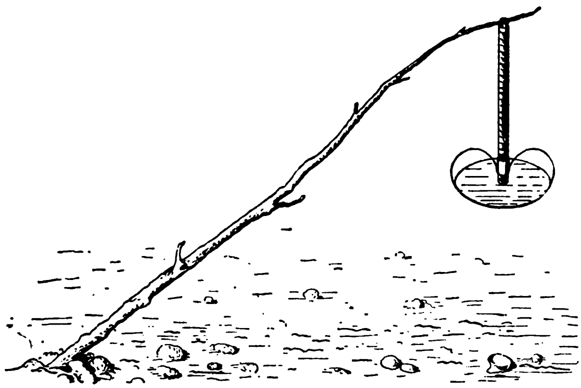

FIG. 43.—Showing the modification of the Piche evaporometer as exposed in the field.

Fig. 43 represents the instrument. Sheets of chemical filter paper were used as the evaporating surfaces; all from the same package and having a diameter of 5.9 inches; this gave an area, after deducting that covered by the graduated tube, of 27.06 sq. in.

The first experiment was made to the northwest of Plainfield on a piece of ground planted to corn, lying to the south of a grove of black oaks having a mean height not far from 12 to 15 feet. At the time there was a gentle breeze from a little west of north. The instruments were all suspended at a height of one foot above the surface of the ground and unsheltered in any way from wind or sun, and in the first trial they were placed at intervals of 20 feet along a line at right angles to the south margin of the woods. The amount of evaporation at the six stations between 11:30 A. M. and 12:30 P. M. is given in the following table:

At Station "A" 20 feet from woods the evaporation was	11.0 cc
At Station "B" 40 feet from woods the evaporation was	11.1 cc
At Station "C" 60 feet from woods the evaporation was	11.3 cc
At Station "D" 80 feet from woods the evaporation was	11.2 cc
At Station "E" 100 feet from woods the evaporation was	11.9 cc
At Station "F" 120 feet from woods the evaporation was	12.9 cc

These results show that there was very little difference in the amount of evaporation between 20 feet from the woods and 100 feet, but at 120 feet away the evaporation was 1.9 cc more in 56 minutes than it was at 20 feet from the woods, or a difference of 17.2 per cent.

Three of the instruments were now set farther out in the field and then the results stood as below:

At Station "A" 20 feet from woods the evaporation was	11.5 cc
At Station "B" 40 feet from woods the evaporation was	11.6 cc
At Station "C" 60 feet from woods the evaporation was	11.9 cc
Sum	35 0
At Station "D" 280 feet from woods the evaporation was	14.5 cc
At Station "E" 300 feet from woods the evaporation was	14.2 cc
At Station "F" 320 feet from woods the evaporation was	14.7 cc
Sum	43.4

These are the amounts of evaporation in one hour and they show that the difference between 20 to 60 feet from the woods and that between 280 to 320 feet, was

$$43.4 - 35.0 = 8.4 \text{ cc.}$$

and this is 24. per cent. greater evaporation at the three outer stations than at the three inner ones. Fig. 38 shows the grove against which the observations recorded above were made.

On May 31st another trial was made in the town of Almond, to the south of an oak grove 80 rods square, in a field sowed to oats and wheat mixed. Here the first instrument was placed 20 feet from the margin of the grove, the second 100 feet distant, the third 200 feet, etc. The first two instruments stood upon ground seeded last year to clover and timothy, but only timothy was growing where the second instrument stood. The grain upon the field had a fair stand where the observations were made and was about four inches high. There was at the time a fair wind from nearly due north and the day was clear. As in the former trials the evaporometers were suspended at a height of one foot above the ground and were unsheltered in any way. The following table expresses the results obtained:

At Station "A," 20 feet from woods, the evaporation was	11.1 cc
At Station "B," 100 feet from woods, the evaporation was.........................	14.3 cc
At Station "C," 200 feet from woods, the evaporation was.........................	15.7 cc
At Station "D," 300 feet from woods, the evaporation was	18.5 cc
At Station "E," 400 feet from woods, the evaporation was	18.5 cc
At Station "F," 500 feet from woods, the evaporation was	18.3 cc

From this table it will be seen there is an increasing amount of evaporation until 300 feet from the woods is reached and that beyond and including this the rate is practically the same, but at 300 feet the evaporation is 17.7 per cent. greater than at 200 feet and 66.6 per cent. greater than at 20 feet from the woods.

Influence of a hedge row on the rate of evaporation to the leeward.— On May 30th three of the instruments were set up to the south of a very scanty hedge row, consisting of a strip of blue grass sixteen feet wide in which there are scattering black and burr oaks from six to eight feet in height, with a few attaining a height of 12 feet. This hedge has very many open gaps in it, and the first instrument is set up behind a clump of six trees, spanning a length of forty feet, there being a gap of nearly the same width on both sides of it. To the north of this, in the direction from which the wind was blowing, there is a broad naked field being planted to potatoes, which has a width of about eighty rods, while the instruments hung over a

field of oats in which the grain was about four inches high. After the instruments were set up it became cloudy and sprinkled a very little, at times, the wind being from a little east of north, rather strong and chilly. Here again the instruments hung one foot above the surface, and the results obtained are given below.

At Station "A," 20 feet from hedge, the evaporation was	10.3 cc
At Station "B," 150 feet from hedge, the evaporation was	12.5 cc
At Station "C," 300 feet from hedge, the evaporation was	13.4 cc

Here it will be seen, the evaporation at 300 feet from the hedge row was 3.1 cc, or 30.1 per cent. greater than at 20 feet distant, and at 150 feet the difference was .9 cc, or 7.2 per cent. less than at 300 feet. It is evident enough, therefore, that even such a hedge row does exert an influence upon the rate of evaporation which is readily measured.

Influence of a clover field upon the rate of evaporation to the leeward of it.—At the same time the last experiment was being conducted, three other instruments were set up to the leeward of a field of clover whose dimensions were 360 feet from east to west and 780 feet from north to south; the evaporometers hanging above the same field of oats. Below are the results obtained here:

At Station "A," 20 feet from clover, evaporation was	9.3 cc
At Station "B," 150 feet from clover, evaporation was	12.1 cc
At Station "C," 300 feet from clover, evaporation was	13.0 cc

Here again there is a very evident influence exerted upon the rate of evaporation at different distances from the field of clover, the evaporation at 300 feet away being

$$13. - 9.3 = 3.7 \text{ cc}$$

or 39.78 per cent. greater than at 20 feet away, and

$$13. - 12.1 = .9 \text{ cc}$$

or 7.44 per cent. greater than at 150 feet away.

It will be observed, too, that the rate of evaporation at the three stations to the leeward of the hedge row where the air came a long way across the naked potato ground was greater in each case than it was from those to the leeward of the clover field, the differences being as given below:

	Station A, 20 feet.	Station B, 150 feet.	Station C, 300 feet.
Hedge-row	10.8	12.5	13.4
Clover field	9.8	12.1	13.0
Difference	1.0	.4	.4

That is to say, the rate of evaporation over the oat field where the air crossed the naked ground and passed through the hedge row was 10.8 per cent. at 20 feet, 3.3 per cent. at 150 feet and 3.1 per cent. at 300 feet greater than it was at corresponding distances to the leeward of the clover field. Now these results are in complete accord with nearly every one of the observations recorded on the preceding pages where the best stand of grain, grass and clover are found to the leeward of woods, hedge rows, grass fields and shelters of other sorts.

THE EFFECT OF WOODS AND GRASS FIELDS UPON THE AMOUNT OF MOISTURE IN THE AIR AT DIFFERENT DISTANCES TO THE LEEWARD OF THEM.

At the same time the observations just recorded were made and in the same localities, readings of the wet and dry bulb thermometers were taken as an indication of the amount of moisture in the air at different distances to the leeward of the shelters in question.

The readings taken at the two groves described above are given below and were made with two thermometers of Henry J. Green's make which are graduated to tenths of a degree centegrade. The observations were made in the open air after swinging the thermometers rapidly to and fro at arm's length one minute at a height of three feet above the surface of the ground. The results here given are the means of ten readings taken alternately thirty feet and 300 feet to the leeward of Grove 1 and in regular rotation at Grove 2.

Table showing the amount of moisture in the air to the leeward of two groves.

At Grove 1.

Distance from Grove.	Mean dry bulb readings, degrees F.	Mean wet bulb readings, degrees F.	Dew point, degree F.	Relative humidity, per cent.
At 30 feet	65.32	49 46	30	27
At 300 feet	63.8	47.35	27	24

At Grove 2.

Distance from Grove.	Mean dry bulb readings, degrees F.	Mean wet bulb readings, degrees F.	Dew point, degree F.	Relative humidity, per cent.
At 20 feet	75.04	58.35	44.6	34.6
At 100 feet	73.13	56.39	44.0	33.0
At 200 feet	72 03	55.83	42.2	34.2
At 300 feet	71.47	55.13	40.6	32.8
At 400 feet	73.63	55 63	29.2	29.6
At 500 feet	73.31	55.94	40.6	30.8

This table shows that the amount of moisture in the air in general decreases as you recede from the grove until about 300 feet is reached, and this of course should be expected from the variations in the rate of evaporation which have been recorded; the rate of evaporation, however, depends in part upon the velocity of the wind, and this too must increase as the distance from the grove increases up to a certain limit. The chief value of the data given in the last table lies in the confirmation they give to the general proposition that groves do exert an influence on the moisture of the air to the leeward of them, which is readily measured.

On the date at which the rate of evaporation was studied to the leeward of the hedge row and clover field the wet and dry bulb thermometers were also read at the south edge of the clover field and also on the potato field just before the air passed through the hedge row, and below are given the means of these readings together with the dew points and relative humidity in each case.

	Dry bulb.	Wet bulb.	Dew point.	Relative humidity.
On edge of clover..................	52.48° F.	43.97° F.	33	48
On edge of potato field	53.24° F.	43.57° F.	31	44

Here, too, the clover field, which was giving moisture to the air moving over it, was pouring out enough more than the naked field by the side of it to be readily indicated by this method of observation, and I have no doubt also to influence growing crops on these soils at such critical periods as are here under consideration.

MEANS OF PREVENTING THE DESTRUCTIVE EFFECT OF WINDS.

The field observations here presented and the experimental data obtained make it very certain that such destructive effects as have this year been experienced in Waushara and Portage counties can be prevented in the future in a very large measure, and this, too, by simple and comparatively inexpensive measures. It is the purpose now to briefly outline some of these:

1. *Frequent rotation in long, narrow lands.* — The fact that large fields, other conditions being the same, have sufered this year much more than smaller ones; the fact that woods, grass-fields, hedge-rows, fences and even stubble fields have offered a marked protection to both clover and spring grain when growing to the leeward of them, when coupled with the fact that groves, grass-fields and hedges do exert a measurable influence upon the rate of evaporation to the leeward, make it practically certain that if the light soils here in question are cultivated in long narrow lands not wider than 15 to twenty rods, alternating with similar strips of grass, which if possible should be largely clover, such destructive effects as were this year experienced could hardly be repeated — certainly not in as much as one quarter of the intensity.

Long continuous fields of dry, naked, sandy soil, in hot weather have a peculiar effect upon the air currents sweep-

ing across them. The sand itself becomes very hot and greatly expands the air coming in contact with it, making it relatively lighter than the colder much more rapid current of air sweeping along above, and the result is, the warm air suddenly blisters, as it were, and being lifted from the ground, a cold current of rapidly moving air from above strikes obliquely upon the surface, raising a cloud of fine dust into the upper swifter current in which the particles are borne away, while the coarser grains are rolled along the surface until the air is slowed down by its friction upon the ground. This air coming down from above has a peculiar parching effect, too, for it is naturally dryer than the ground air and striking the hot soil its parching power is greatly augumented by the heat it so receives.

Grass covered surfaces and damp soils do not become overheated as the dry sands do, and the result is, during windy times, the air moves across them in a more steady and less turbulent manner. These being the conditions, it is evident that by cultivating the sandy soils in question in alternate narrow strips, with grass between, the first effect will be to lessen the turbulent character of the surface wind, and then when the "blistering" referred to does occur, it is most likely to take place near the windward edge of the grass strips, so that when the rapidly moving upper current comes down with its oblique trust it is likely to either strike first upon the grass or else to pass quickly upon it where, instead of being heated and rendered more parching, it will become more moist, and at the same time cooler before passing upon the next naked strip.

In whatever direction the narrow fields are made to extend, they must have a tendency to counteract the liability to drift, but the fact that the observations in the many fields examined show the best stands of both old and new seedings to clover, and the best stands of spring grain are to the east and south of shelters of all sorts, and especially to the east of grass fields, hedge-rows and groves, makes it appear that, generally, it would be better to extend the fields north and south rather than east and west. The general fact, too, that winds which come to this section

from a direction to the west of a north and south line are, usually, more drying, stronger, and of longer duration than those which come from the south of an east and west line, also indicates that in most localities the strips should preferably extend north and south.

The difficulty of cultivating corn and potatoes in rows both ways should have no weight against the handling of long narrow fields, because the extreme ease with which the soils in question are worked and the perfect safety in cultivating them almost immediately after even heavy rains, make it possible, when the method is understood and the habit fixed, to tend both corn and potatoes with much less labor when rowed only one way.

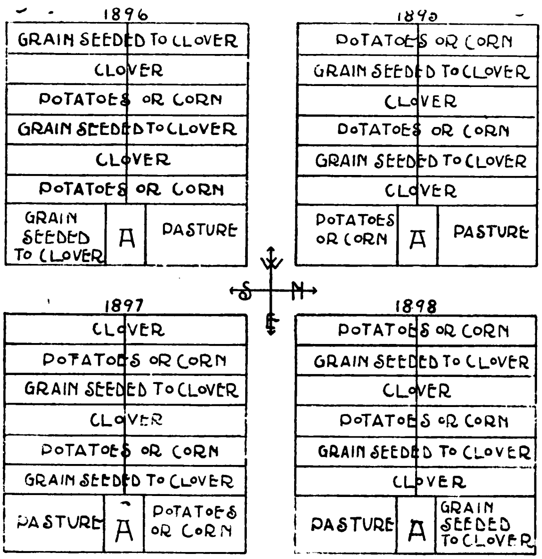

FIG. 44.—Showing plan of rotation to avoid drifting.

There are so many individual conditions which enter into the general problem of rotation that it is not practicable to devise a general plan which would be applicable in individual cases except in particular instances. It will be helpful however, to consider a plan that could be adopted under certain conditions by way of suggestion, and with this in view Fig. 44 represents 160 acres of land lying in a square, which has been divided into narrow fields, north and south, with

the farm buildings at A. In this case it is assumed that only a small amount of stock will be kept and that potatoes are the chief crop. It will be seen that the quarter section is practically thrown into 20 acre fields each 20 rods wide and 160 rods long, but that all of the fields are divided crosswise in the center by a roadway or lane. On the east side where the farm buildings are located two of the fields are thrown together for pasture purposes and these form a system of rotation by themselves, while the remaining ones form a second system.

The aim of this rotation is to always have in the spring a field of grass to the west of those which are to be sowed to grain and seeded to clover, and this is secured by always planting potatoes or corn on clover sod, for the latter going in later in the season allows the clover to stand as a protection while the grain is getting started when the most serious damage is done and at the same time furnishes a green manure to plow in to increase the humus of these soils, in which they are naturally so deficient. The pasture rotation contemplates a strong windbreak along the west side as a permanent protection which may allow these fields to have a greater width so as to avoid having so much fence.

It will be seen that this system of rotation may also be applied to 80 acres by having 10 acres always in pasture instead of 20 acres. So, too, it could be applied to 40 acres by having 5 acres always in pasture.

In the table below are given the number of acres which could be devoted to the several crops each year:

Crop.	160 Acres.		80 Acres.		40 Acres.	
	1st Year.	2d Year.	1st Year.	2d Year.	1st Year.	2d Year.
Potatoes	40	30	20	15	10	7.5
Corn	20	10	10	5	5	2.5
Clover	40	40	20	20	10	10
Grain	40	60	20	30	10	15
Pasture	20	20	10	10	5	5

Of course this assumes no waste land and does not take into the account the land occupied by the farm buildings or fences.

2. *Increasing the water-holding power of the soil.* —It is the small water-holding power of these soils which is at once the cause of this drifting, and the extreme difficulty in getting and maintaining a good stand of clover, and it should never be forgotten that the more these fields are allowed to drift the less their water-holding power becomes and the greater the tendency to drift in succeeding years. When the strong winds are on and drifting occurs the finest of the fine particles are lifted high in the air and borne permanently away, only the coarsest of the fine particles falling in the woods and sheltered places of adjacent fields; and yet it is the finest particles which are by far the most important in increasing the water holding power of the soil by giving a broad surface to which the water may adhere. This will be readily understood from what follows: Take a spherical pebble 1 inch in diameter; it will just slip inside a box one inch on a side and will hold a film of water 3.1416 square inches in area. But taking pebbles .1 inch in diameter and 1,000 of them, having an aggregate surface area of 31.416 square inches, will be contained in the same cubic inch. If, however, the soil particles are all spheres .01 of an inch in diameter there may be placed in a cubic inch 1,000,000 of them, and their aggregate surface area will be 314.16 square inches.

Supposing again the soil particles to be spheres all having a diameter of .001 of an inch it will requere 1,000,000,000 of them to fill the cubic inch and the aggregate surface of these will be 3,141.59 square inches. The finest soil particles do have diameters which are less than .00001 of an inch and the number of these per cubic inch is one billion million, having an aggregate surface of 314,159 square inches, equal to 2,181 square feet, or about one-twentieth of an acre. Now when it is remembered that the water which the roots of plants use is, in a very large degree, that which simply adheres to the surface of soil grains, the importance of a large soil surface can be appreciated and also the great

need, on these soils naturally so deficient in fine particles, of adopting such means as will prevent the fine dust from being carried away by the winds. Each time the field is plowed, each time the soil is stirred, more of the finest particles are brought to the surface where the winds may carry them away so that the natural tendency is for these soils, if allowed to drift, to become coarser, less able to retain water and more subject to drought. But this tendency brings in its train increased losses in three other important directions. The weathering action of moist climates has a constant tendency to break down the stones, gravel and coarsest soil grains into the finest dust, but on open soils and especially where the subsoil is gravelly the heavy rains in their rapid percolation downward tend to carry these deep into the ground where they are lost to the agriculture of the present time, and yet it is these very particles which in all soils absorb and hold for the roots of plants the soluble substances so much needed. Then again in open soils like those in question, when they are allowed to become dry and hot the organic matter tends to completely oxidize and fail to form the dark humus which is so distinctive a feature of fertile soils in all humid climates. These being the facts it must be evident that whatever augments the drifting of these soils should be avoided. and that in handling such soils as these factors and methods which would be insignificant on the heavier soils must here be recognized as of great moment. I have found, for example, with columns of sand eight feet long and of five degrees of fineness, when filled with water and allowed to drain, that that which passed through a screen of twenty meshes to the inch and would not pass through one of forty, lost in twenty-four hours 65 per cent. of all its water; one which would pass a screen of forty meshes, but was held by one of sixty to the inch, lost 61.5 per cent.; a third which passed a screen of sixty meshes, but was held by one of eighty, lost 55.8 per cent; one which passed through a screen of eighty meshes, but was retained by one of.100, lost 38.2 per cent., while the one which passed through a screen of 100 meshes to the inch lost 29.2 per cent. in the same time. The coarsest sand

here considered is about like that which is left on the fields where they have drifted badly, while the finest sample is more open than the natural undrifted soils of the region in question.

The great advantage of farm-yard manure and of green manuring on these soils comes as much from the tendency which organic matter has of increasing the water-holding power so that the summer rains do not run away downward so rapidly, as from the other plant food which is supplied, important as that is.

The plowing in of green clover and even of the dock sorrel which comes up where the crops have failed helps to increase the humus and the water-holding power, and so to stop the drifting. The clover gathers large quantities of carbon from the passing air, which, when plowed in, becomes the humus so much needed; the potato crop on the contrary gathers but little for its top is very succulent and contains little dry matter.

Frequent rotations then, such as have been suggested, are, on these soils, very essential, not simply to stop drifting through the protection offered by their mechanical effects upon the winds, but because they offer the only practicable means of keeping the humus of these soils up to an economically productive standard.

3 *Leaving the ground uneven after seeding* — The smoother the ground is left after it has been worked the greater is the velocity of the wind close to the surface and the greater the velocity of the wind close to the surface the greater is its power to take up and carry away the soil particles.

Measurements of the velocity of the wind made on rolled and on unrolled ground at the Station farm give the following results:

Surface velocity of air.

	On rolled ground.	On unrolled ground.	Difference.
Series 1—Mean velocity per min	628 feet.	405 feet.	233 feet.
Series 2—Mean velocity per min	676 feet.	316 feet.	360 feet.
Series 3—Mean velocity per min	399 feet.	275 feet.	124 feet.
Mean	571 feet.	332 feet.	239 feet.

Here it will be seen that the velocity of the air over the smooth ground was more than 40 per cent. greater than it was over the rough surface, and this being true its power to dry the soil, to wilt and kill young clover plants and to pick up and carry away the fine particles of soil is much increased.

While at Almond on May 31st there were two fields which were drifting badly under a moderately strong wind, and one of these the writer visited. This field had been planted to corn and when marking it the runners had cut so deeply into the soil as to allow the top of the marker to smooth the surface much as if it had been rolled and the field had not since been harrowed. A slight crust had formed over the smooth surface and the corn was from one to two inches high at the time. So great was the cloud of dust raised from this field by the northwest wind that, looking across it toward the east, not an object on the horizon could be seen, and Fig. 39 is from a photograph taken at the time, while Fig 40 is a view taken looking in the same direction across the same field after the cloud had subsided between gusts of wind.

Adjoining this cornfield on the north and across which the same wind passed before reaching the drifting field was a piece of ground planted to potatoes, but with the surface left uneven and here no drifting was appreciable, and the same thing was also true of a cornfield adjacent to the field of potatoes which had been harrowed after planting. Figs. 41 and 42 are photo-engravings which show the difference between the surfaces of the two fields, one of which was drifting while the other adjacent to it was not. It will be

seen that the coarse sand has drifted into the marker tracks in many places completely covering the corn, while the fine material which was associated with it has been swept away. On the other field no sign of drifting can be seen.

While the drifting was in progress the writer had the owner hitch to his harrow and harrow a strip across the field, the effect of which was to stop the drifting at once wherever the soil was stirred. These observations indicate that sowing the grain with the drill north and south would have a tendency to lessen very materially not only the drifting but also the parching of the young clover plants, and that under most circumstances the surface of the fields should not be left smooth.

I am told by Mr. Fred Frost of Almond that a farmer between that place and Waupaca went over his grain fields with a heavy roller while they were drifting badly, and that he thinks it saved his crops. In the face of the facts here presented this statement appears strange and the surrounding conditions and the character of the soil need to be known before it is safe to ascribe the saving of the crop to the rolling. However, in view of the fact that there had been so recent a heavy rain and, if this soil was especially loose and open, it is not impossible that the immediate effect of the heavy roller was to bring enough moisture back to the surface, for the time, to counteract the drying effect of the greater velocity of the wind and to prevent the plants from being parched, but this experience should not be taken as a safe rule of action until the attendant conditions are better known.

4. *Clearing the wooded lands in north and south belts.* — In view of the facts which have been presented it seems very evident that the wooded lands which are now being so largely cut away in order to increase the acreage for potatoes ought, in part, to be preserved. Where the clearing is done it ought certainly, for the present at least, to be done in strips north and south, leaving belts as windbreaks to stop the drifting and to make surer a crop of the all-important clover. The width of the wooded strips to be left as hedge rows would depend upon the character of the soil

and upon the width of the strips that are cleard; the lighter the soil is and the wider the cleared fields the broader the hedge-rows should be.

Where 80 acres or a quarter section is to be cleared the prudent thing to do would be to commence by dividing the whole into north and south lands not wider than 20 rods and to clear these, leaving belts a full rod in width, at first; and because the destructive winds are occasionally nearly north or south, I should leave a hedge-row also along the north and south lines of the fields, but these not closer together than every 80 or 160 rods. No serious mistake can be made in adopting this plan because it entails no material expense, and if after the trial is made it is found that the shelter is not of sufficient benefit to pay for the use of the land the trees which have been left standing may be taken out at any later time. On the other hand when the trees are once cut it will not only be expensive to replace them but will require years of time and care to do so.

In the case of the smaller groves which are now left standing to supply the fuel or to be used as pastures for the time being, it seems to the writer much the better plan to cut out strips at intervals through these pieces and seed them to grass and clover if intended for pasture, or to crop them if that is desired rather than to do as many are now, clearing off a strip each year from one side of the woods, thus making the open fields broader and the woods narrower so that the force of the winds is made to increase while the shelter against them is decreased.

The protection offered against the force of the winds is relatively greater by alternate narrow wind-breaks with fields between than by broad pieces of woods, and why this is so will be understood from an inspection of Fig. 44. Every obstruction thrown across the course of air currents produces a slackening of the wind movement and often a complete reversal of the direction of it, as indicated by the arrows in the figure; the air breaks against the trees on the windward side and the main current is thrown upward above the surface producing a region of slack or reverse movement even on the windward side, and thus the de-

structive power of the wind is reduced, and hence narrow strips of wood left in parallel rows with fields eighteen to twenty rods wide between them, as has been suggested, will greatly reduce the force of the wind and lessen the destructive drifting of the light soil.

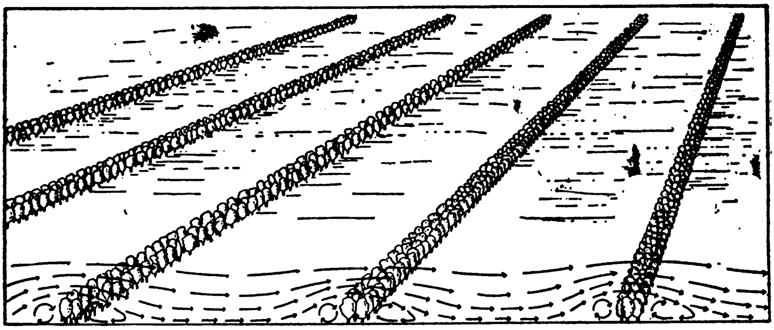

FIG. 45.—Showing the effects of wind-breaks on air currents passing across them.

The planting of wind breaks.—The facts which have been observed and recorded in this paper regarding the protection offered by scanty hedge-rows, board and even half-wire fences make it evident that well developed wind-breaks especially in the prairie sections would offer very material protection if properly disposed, and if the seeding and rotation in narrow fields which has been suggested does not furnish the relief which is needed it may be found necessary to resort to them. Certainly the influence of those now standing ought to be observed with great care and the destruction of them which is now going on ought to be stayed for the present at least. While I would not now urge the dividing of the broad open fields by lines of trees similar to those which it has been urged to leave when clearing the present wooded sections I do believe that no mistake would be made if on the prairies the section and quarter section lines were planted to them. The planting of trees along the roads has the objection that they tend to cause the snows to block them up in winter. To obviate this difficulty and to get the full advantage of the shelter from the trees the rows along the road should be planted far enough back on either side to permit the drifts of snow

to lodge upon the fields and to allow the snow covered strips between the trees and the road to be regularly cultivated. While this method would obstruct the fields somewhat, and take out of use more land than if the trees were planted close to the road the advantages gained are likely to more than compensate for the losses.

The Box Elder thrives naturally upon light soils, is a rapid grower, can be raised easily from the seed and on the whole is one of most promising trees for these soils, although the Jack Pine which is indigencus here would make an excellent wind break if the trees could be readily started. It seems a pity we have no perfectiy hardy apples which could be set along fences for they must be able to offer a very material protection besides yielding a crop of fruit. Our better varieties of native plums, like the Weaver and De Soto and Forest garden do produce choice fruit and they will grow in a close enough hedge to act as an effective wind break while they are claimed to be hardy. The English Filbert thrives upon light dry soils and grows naturally in hedges, but has never been tried here, although its natural geographical distribution would lead us to expect that it might thrive on these soils.

EXPERIMENTS IN STRAWBERRY CULTURE.

E. S. GOFF.

Our strawberries are grown on a light clay loam, well, though not excessively fertilized with stable manure. The plants were set in the spring of 1892, and were permitted to form matted rows, as is common with the market growers of Wisconsin. Good culture has been given, and the plants have been well protected during the winter. The report here given is, except as otherwise stated, the average of two crops—of the crop of 1893 and 1894. The rows are fifty feet long, except as otherwise noted, and the plants were originally set two feet apart in rows three and a half feet apart.

A TEST OF VARIETIES.

No attempt has been made to make our list of varieties complete. Only those have been planted which seemed for some special reason to merit trial. A few have been tested that are not here reported, not being strictly comparable with the others. To avoid the use of tables, which to many readers are unsatisfactory, the comparative productiveness, the dates of maturity and length of bearing season are shown in the accompanying diagrams, which will be readily understood.

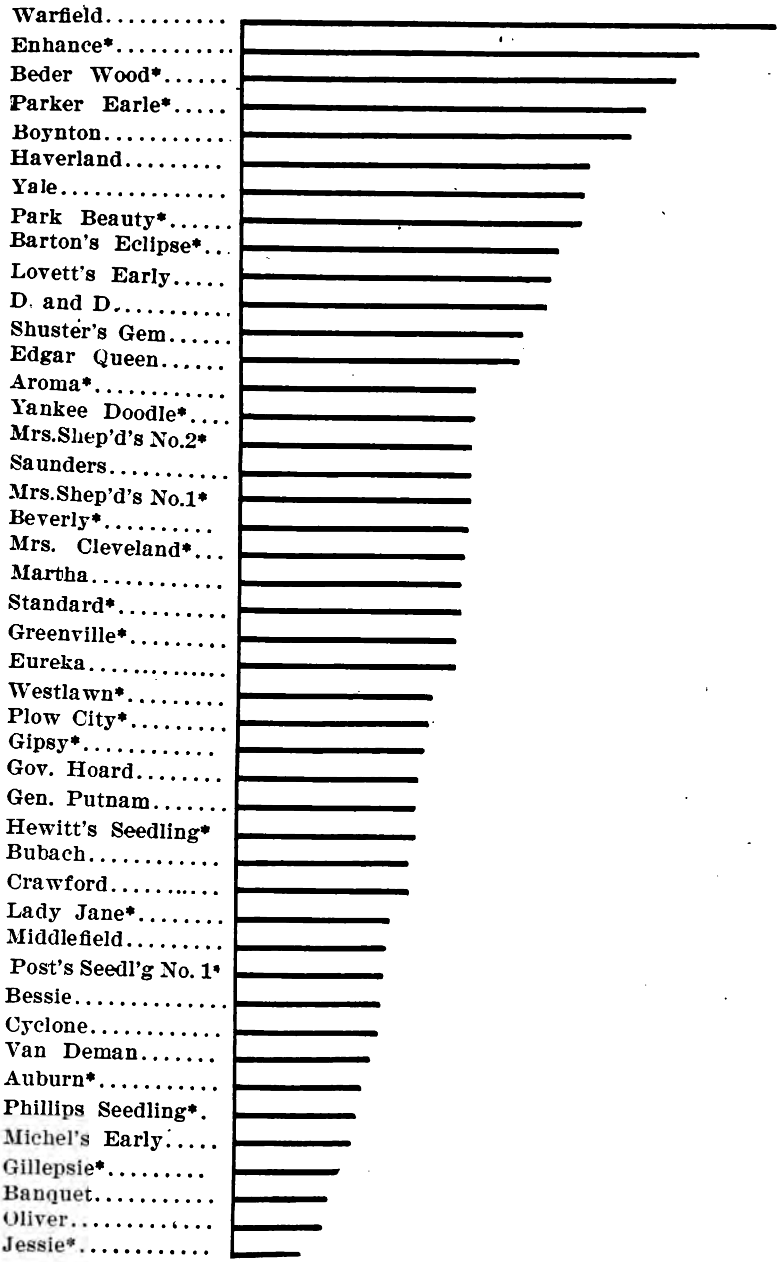

FIG. 46—Showing comparative yields of strawberries for 1893 and 1894.—The average of two crops.

Rows 25 feet long calculated to 50 feet.

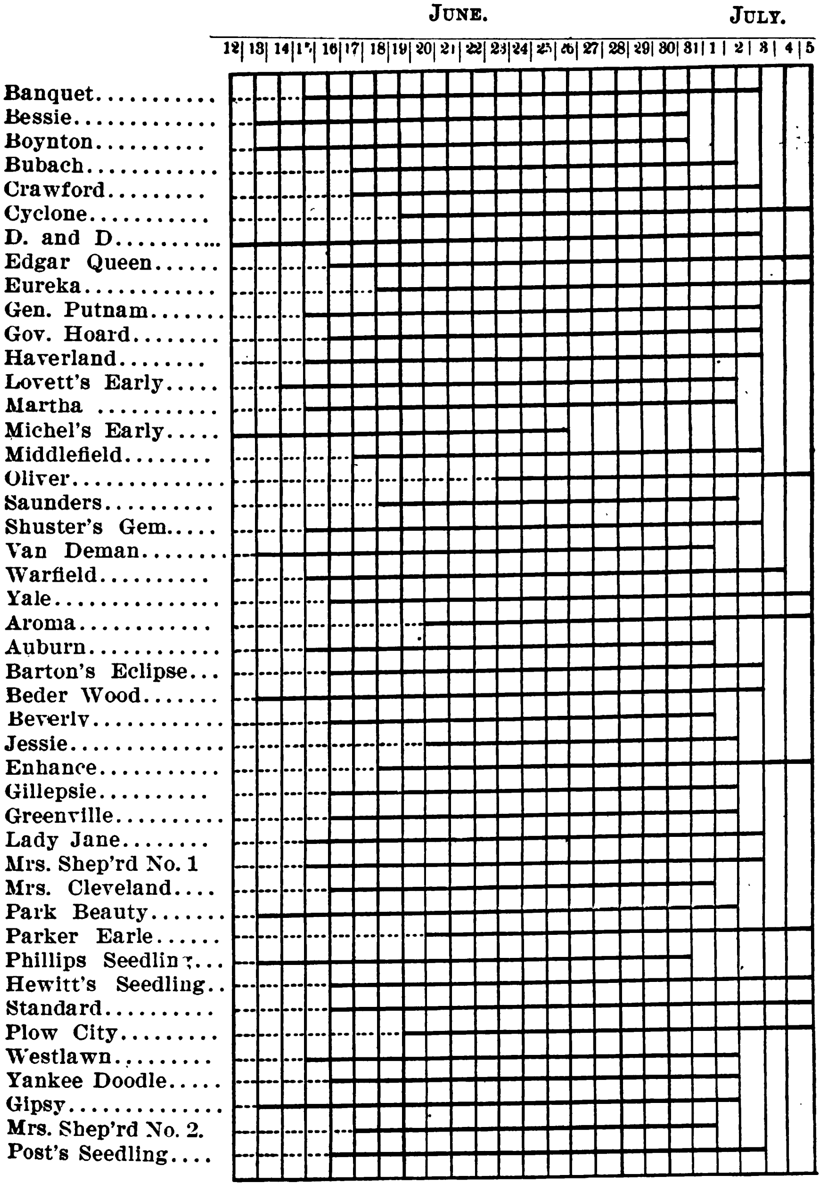

FIG. 47—Showing the fruiting season of the different varieties of strawberry. The dates appear at the top, and represent the average of two season's trials.

We have thus far found nothing to equal the Warfield, as a general purpose strawberry. Its great productiveness, firmness, regularity of form and high color commend it most highly, as grown on our grounds. The average yield for the past two seasons has been at the rate of something more than 333 bushels per acre. While the yields of the varieties named in our list have been noted with much care, it is well to offer a caution to the reader against accepting them as a safe criterion for what the same varieties may do on soils differing in character from ours. Certain varieties, as the Warfield, yield well on soils that differ much in character, while others, as the Jessie, do well only on particular soils. A neighbor who grows strawberries for market a mile distant from our Station, on a light, sandy soil, succeeds admirably with the Jessie, which is nearly a total failure with us.

A TEST OF KEEPING QUALITY.

In addition to the comparisons of yield and season, shown in the above diagrams, a test of the keeping quality of the fruit was made in 1893. A sample box, freshly picked, of the different varieties, from which all over-ripe and immature specimens had been carefully rejected, was placed on a shelf in a north room of the farm dairy building, on June 26. The weather was moderately warm, the mean of four daily readings being about 70 degrees F. for each of the four days, and with a mean relative humidity of 60 per cent. After twenty-four hours the fruit in all of the boxes was examined, and the varieties assorted into three qualities, with reference to the damage suffered from the exposure. Those placed in the first quality were to all appearances as fresh as when picked; those in the second showed slight withering at the top of the box, while those that had suffered more or less throughout the box were placed in the third quality. No decay had taken place at the time of this examination, which resulted in the following classification:

First quality.	*Second quality.*	*Third quality.*
Aroma,	Barton's Eclipse,	Banquet,
Auburn,	Beder Wood,	D. and D.,
Boynton,	Bessie,	Enhance,
Crawford,	Beverly,	Gen. Putnam,
Eureka,	Bubach,	Gov. Hoard,
Gillepsie,	Cyclone,	Lady Jane,
Haverland,	Edgar Queen,	Martha,
Park Beauty,	Gipsy,	Michel's Early,
Post's Seedling,	Greenville,	Mrs. Cleveland,
Saunders,	Hewitt's Seedling,	Mrs. Shepard No. 1,
Warfield.	Jessie,	Phillips' Seedling,
	Lovett's Early,	Shuster's Gem,
	Middlefield,	Yale.
	Mrs. Shepard No. 2,	
	Parker Earle,	
	Pearl,	
	Plow City,	
	Standard,	
	Van Deman,	
	Westlawn,	
	Wilson,	
	Yankee Doodle.	

It should be remembered that this test is not one of carrying quality, but rather one of ability to endure exposure to moderately warm and dry air.

Twenty-four hours later, or forty-eight hours from the beginning of the test, the samples were again examined, and a second classification made,—necessarily upon a lower and somewhat more arbitrary standard, as some varieties were now considerably decayed, while others though less decayed were badly withered or spotted. Those placed in the first quality, however, were still in fair salable condition, and those in the second were still usable — while the third would have been rejected at any price by most purchasers. The result of this second classification was as follows:

First quality.	*Second quality.*	*Third quality.*
Aroma.	Auburn.	Banquet.
Beder Wood.	Bessie.	Beverly.
Enhance.	Boynton.	D. and D.
Eureka.	Bubach.	Edgar Queen.
Greenville.	Cyclone.	Gen. Putnam.
Haverland.	Gillepsie.	Lovett's Early.
Lady Jane.	Gipsy.	Mrs. Cleveland.

First Quality.	*Second Quality.*	*Third Quality.*
Mrs. Shepard No. 2.	Gov. Hoard.	Mrs. Shepard No. 1.
Plow City.	Hewitt's Seedling.	Yale.
Post's Seedling.	Jessie.	
Warfield.	Martha.	
Westlawn.	Michel's Early.	
	Middlefield.	
	Park Beauty.	
	Parker Earle.	
	Phillip's Seedling.	
	Standard.	
	Shuster's Gem.	
	Van Deman.	
	Wilson.	

A few varieties appear in a higher quality in the second classification than in the first. This is explained by the fact that the withering, which condemned them to the lower quality in the first assortment, appeared to preserve them from decay, and thus gave them a higher standing at the second examination.

AN EXPERIMENT IN IRRIGATION.

As is well known, the strawberry plant quickly suffers from an insufficient water supply—an event which, in our climate, frequently occurs in June—the most critical time for the strawberry harvest. Rather late in the summer of 1893, arrangements were made for irrigating our small fruit grounds from Lake Mendota, to which they are adjacent, and in 1894 our strawberry beds were irrigated. A rotary pump, of a claimed capacity of fifty-five gallons per minute at one hundred revolutions, was connected by a three inch suction pipe with the water of the lake, and a two and a half inch discharge pipe was laid from the pump to the strawberry plantation, where it connected with the line of wood troughs that served to distribute the water to the different rows. The pump was operated by a ten horse-power threshing engine, though one of half this capacity might have done the work. The results of this experiment proved so satisfactory that it seems well to describe it in some detail, not that the method is new, but that the subject is one of great importance to the small fruit growers of Wisconsin.

The ideal ground for irrigation slopes regularly but very gently in two directions, though such land is by no means the only kind that may be successfully irrigated. The soil should be well cultivated at the beginning, in order that the water may be readily absorbed by it, and the cultivator should be fitted with teeth that make a light furrow on each side of each row of plants.

FIG. 48—Showing method of irrigating strawberries.

The half-tone illustration (fig. 48) will help the reader to understand many details of the work, as we performed it. The water, falling from the distributing troughs in small streams, flows slowly along the shallow furrows on either side of the matted strawberry rows, permeating the mellow soil as it proceeds and soaking in among the roots of the plants without puddling the surface, but leaving it more porous and permeable to air than after a rain. The attendant with his hoe directs the course of the streams as they need it, walking the while on dry ground. There is no undue packing of the soil and no puddling of any part of it.

The distributing troughs are an important part of the outfit, hence these are described in detail. They are made of inch boards of common quality which need not be dressed. As the bulk of water decreases in its forward movement through the

troughs, those farthest from the supply may be made of narrower boards than the others. Our troughs are of two sizes—the larger being made of one twelve inch and one ten inch board, and the smaller of one ten inch and one eight inch board. The boards should be nailed together strictly at right angles, and cleats should be nailed across the top, one at the center and one near the ends of each trough, to keep the boards from spreading.

As will appear from the illustration, the end of one trough sets inside that of the next. Some trouble was experienced in preventing leakage at these unions, but generally a little dirt, or a strip of building paper placed between the overlapping boards stopped the escape of water sufficiently at these points. The ends of the troughs are supported at the proper height by stakes driven in slanting and crosswise of each other; each of these stakes has a row of small auger holes through its center about three inches apart, so that by slipping an iron spike through the pair of stakes at the proper point they are readily joined together at the desired height. The stakes are driven into the ground sufficiently to prevent them from falling over sidewise, and a tie strip, not shown in the illustration, should be pinned across from one stake to the other just at the surface of the ground to prevent the bottoms from spreading or from settling too far into the ground, as they are sometimes inclined to do after the soil becomes wet. This tie strip should have a row of small holes along the center like the stakes, to which it is attached with spikes.

The water flows from the troughs through three-quarter inch augur holes on one side, near the bottom, and spaced three and a half feet apart. It is important that these outlets be under ready control, in order that the water may be evenly distributed to the different rows. This is accomplished by the little device shown in fig. 49. It is made of two small pieces of thin galvanized iron, A and B. A has a three quarter inch hole through it, half an inch from its lower edge, and the side edges are bent over, so that B which has its upper edge bent forward at a right angle to form a handle, may be slipped in and thus form a gate to shut off the hole more or less

at will. This device is tacked with clout nails to the inside of the trough so that the hole exactly coincides with the one through the board that forms the side of the trough. If the attendant discovers that one row of strawberries is receiving more than its share of water, he partially closes the gate at the end of this row, and if another row is receiving too little, he opens its gate more. A sufficient length of trough should be used so that the holes can discharge all of the water delivered without being open to their full capacity.

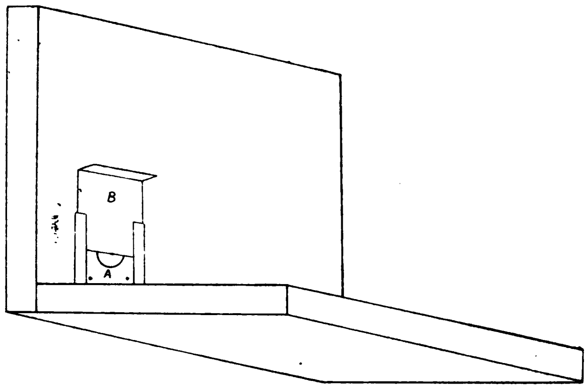

FIG. 49—Showing device for regulating the flow of water.

We have found it more satisfactory to apply the water slowly, over a larger area at once, and thus give it ample time to soak into the ground, than to apply it faster over a smaller area. From ten to twelve hours of pumping were required to thoroughly wet the soil for one-fourth of an acre of strawberries, and the water generally came through the two and a half inch pipe under considerable pressure. This will convey some faint idea of the large amount of water required for irrigation in dry weather.

EFFECTS OF IRRIGATON UPON THE YIELD.

Our strawberries were irrigated for the first time June 11, just as the fruit was beginning to ripen. At this time no rain had fallen since May 23—a period of eighteen days, and the plants were just beginning to show the effects of the

drought. The plants immediately resumed their fresh and vigorous appearance, and yielded a fine crop of excellent fruit. No further watering was needed until after the picking season, the drought having been relieved by rain on June 16th. A portion of our strawberry plantation was left without irrigation as a check by which to judge the benefits received from the irrigation. One plat of eighteen rows Warfield and Wilson, was irrigated on June 11.* A second plat of 9 rows of the same varieties planted on the same day, and with the same stock of plants was not irrigated at any time. The rows were 50 feet long. Multiplying the yield of the rows not irrigated by two to make the areas comparable, we have

18 rows irrigated yielded	496.6 quarts.
18 rows not irrigated yielded	252.8 quarts.
Difference in favor of irrigated rows	243.8 quarts.

The effects of the irrigation appear conspicuously from the accompanying graphic diagram. The difference in yield does not express the whole benefit from the irrigation, since the berries from the irrigated rows were decidedly larger than those from the rows not irrigated, which much enhanced their market value.

FIG. 50—Showing effects of irrigation on the fruitfulness of strawberries.

From the limited trials thus far made it would be difficult to accurately estimate the cost of the irrigation. A fair estimate of the labor required would be three men, working one day, for each half acre irrigated. This includes the labor of running the engine, of setting up and removing the troughs, and the distribution of the water. The fuel and interest and wear and tear of pump, engine, and fixtures must be added. There is no question that the irrigation of our strawberry grounds proved highly profitable, since the crop on other plantations in the neighborhood, that were not irrigated, proved nearly a failure.

* These rows were also irrigated August 2 and 8, 1893.

After the berry harvest, the plantation looked so well, that, though it had already borne two full crops, it was decided to mow and burn it over, thin out the plants in the rows and allow it to remain for a third crop—as a further experiment in irrigation. Almost no rain fell until near the middle of September, and with the exception of the check rows, the beds were thoroughly irrigated on July 12 and 16, and August 17. The plants made a most vigorous growth, and during the latter part of the summer, when the severe drought had destroyed nearly all green herbage, presented a most refreshing appearance,—looking far more promising than spring set beds that had not been irrigated. The check rows, on the other hand, were nearly ruined—long vacant spaces appearing in some of the rows, whence every plant had perished from the protracted drought.

A BREEDING EXPERIMENT WITH STRAWBERRIES.

In the report of this Station for 1892, pp. 284-87, is described an experiment in growing the Wilson strawberry from different strains of plants, i. e., plants of which the parents had been differently treated in the past, and had suffered to varying degrees from disease. It was shown that the amount of inherited vigor a strain of plants possessess has much to do with their development. This experiment has been continued up to the present time.

THE INFLUENCE OF CROPPING UPON VIGOR.

The late J. M. Smith held that new strawberry beds should always be set with plants grown from other plants that had been set the preceeding spring, and which had consequently not borne fruit, a view that our experiment above cited seemed to corroborate.

In the spring of 1892 two rows of 25 plants each were set from a bed of Wilson strawberries of which the ancestors had been grown for many successive generations in the manner above described, i. e., from young plants that had not borne fruit. It is known to a certainty that the ancestors of these plants had not borne fruit since 1889, and according to Mr. Smith they had not for many years previous to that date. At

the same time one row was planted with the same variety but with plants taken from a bed that was known to have borne two crops, and which was originally planted from a bed known to have borne one crop. Prior to this, the history of this strain is unknown.

The two rows above mentioned contained in the spring of 1893, 965 living plants, or an average of 19.3 plants for each one originally set, while the one row contained but 333 living plants or an average of 13.3 plants for each one originally set. The difference in the yield of fruit from these rows was less marked, possibly owing to the fact that the plants from the more vigorous rows were more crowded.

In the spring of 1893 one row of twenty-five plants was set from the strain of Wilson strawberry spoken of in the article above cited that has been much reduced in vigor by the "spot disease" or blight, and at the same time another row was set of the same number of plants from the healthy strain so long propagated from young plants. The following spring (1894) the first of these rows had 232 living plants—a little more than 9 plants for each one originally set; while the second row contained 460 living plants, or almost exactly twice as many, and the yield of fruit from the two rows was nearly in the same proportion.

The results of this experiment are significant because they show that the vigor and prolificacy of plants is to some extent dependent upon parental endowment, which emphasizes the importance of procuring plants and seeds of vigorous and healthy parentage.

THE BORDEAUX MIXTURE AS A PREVENTIVE OF STRAWBERRY BLIGHT.

The affection of strawberry plants known as "blight," "rust" or "spot disease,"* and due to the fungus known as *Ramularia tulasnei, Sacc.* is a serious one in this state, strawberry-beds of more than one year's standing often being nearly or quite destroyed by it.

* For description of this disease see Report Wis. Expt. Sta., 1893, p. 248.

During the summer of 1893 a plantation of strawberries comprising one-fourth of an acre was divided into two equal parts in such a manner that each row was divided at the center. One of these parts was thoroughly sprayed with the Bordeaux mixture on April 15, May 6, May 24, and July 29. The formula used was three pounds copper sulphate to twenty-two gallons of water.

The results were entirely negative. Late in the summer all of the rows were more or less affected with the blight, but not the slightest difference was discernible between the sprayed and unsprayed part of the bed. Observation was made early last spring (1894) of the new growth, to see if this showed any influence of the spraying, but no such influence could be detected.

The past season our strawberry beds were mowed and burned over after the berry harvest, and the new growth that came on promptly from the well irrigated soil, was almost entirely free from blight, notwithstanding that the bed had already borne two large crops of fruit. From this I am led to infer that the most satisfactory preventive of blight is to burn over the strawberry bed after the berry harvest, thus destroying all diseased leaves, and then to provide abundant water to stimulate a vigorous new growth.

NOTES ON ORNAMENTAL TREES AND SHRUBS.

E. S. GOFF.

The following observations as to the hardiness of some of the more recently introduced trees and shrubs will have interest to those who desire to improve their home grounds.

The Purple-leaf Plum, *Prunus Pissardii*, grew finely for two seasons after planting, but perished during the winter of 1892-3.

Two specimens of the Ginkgo, or Maidenhair tree, *Salisburia adiantifolia*, set in the spring of 1892, have thus far endured the winters without harm.

Teas' Weeping Mulberry, *Morus alba*, var., planted in 1892, appears thus far to be perfectly hardy, and forms an attractive and interesting lawn tree, especially well adapted to small grounds.

The Amure Tamarisk, *Tamarix Amurensis*, kills back more or less each winter, but quickly recovers in the spring, forming a beautiful shrub that remains in bloom more or less all summer. While its flowers are not conspicuous its light, airy foliage makes it an interesting addition to the lawn.

The Golden Elder, *Sambucus nigra*, var. *Aurea*, though not strictly hardy, is sufficiently so to form a very attractive shrub. The shoots kill back nearly or quite to the snow line each winter, but a vigorous crop of young canes grows from the roots in spring, and the mingling of the younger green and older yellow foliage is strikingly beautiful. Later in the season, the leaves are sometimes attacked by a blight that mars their appearance to some extent. The canes are also injured by a borer.

The Golden-Leaf Syringa, *Philadelphus coronarius*, var., endures the winter with little harm, but the foliage blights

considerably in the latter part of summer, causing the shrub to develop slowly. It is evidently not at home in our climate, and while beautiful for its foliage cannot be recommended.

Deutzia crenata, and *D. gracilis* are satisfactory only with winter protection. Without this the shoots often kill back nearly or quite to the ground.

Viburnum plicatum must also receive winter protection if it is expected to thrive.

Eleagnus longipes endured the past winter without other harm than the destruction of most of the flower buds. Plants well protected with earth during the winter bore a large crop of fruit the past season, while those not protected bore little. The chief interest of this shrub lies in its fruit, which ripens in June, resembles a small plum and is rather attractive on the plant, besides being edible. Though relished by some persons, it is too sour and astringent to be generally popular. I think the plant is worthy of attention, not so much for what it is at present as for what it may become by improvement.

A variety of *Rosa rugosa* received from Prof. J. L. Budd in the spring of 1892 has thus far proved entirely hardy without winter protection. It produces a profusion of large, single, deep rose-colored flowers in June, and occasionally blossoms later in the season. On the whole this is one of the most valuable ornamental shrubs we have planted.

Van Houtten's Spiræa, *Spiræa Van Houttei*, has thus far proved quite hardy and forms a most attractive shrub while in bloom. Its profusion of pure white flowers which appear in June are conspicuous as far as the plant can be seen.

The Large-Panicled Hydrangea, *Hydrangea paniculata grandiflora*, endures the winter well, but unless given plenty of water in the summer is liable to suffer much from our protracted droughts. With proper care the panicles attain large size and are very attractive, but otherwise they are small and fail to open well in dry seasons.

The Yellow Wood, *Cladrastis tinctoria*, growing in a sheltered location on our grounds, seems entirely hardy. It forms an interesting tree of small size, and its long, droop-

ing racemes of purple flowers which appear in June are decidedly attractive.

The Japan Ivy, *Ampelopsis tricuspidata*, cannot endure our winters without some protection, but where this is given, is not an entire failure. There is not much hope, however, that it can ever prove satisfactory with us, even in sheltered locations.

Among our evergreens, *Abies concolor*, is evidently not hardy as a young tree, as it kills back more or less every winter. Engleman's Spruce, *Picea Englemanni*, however, seems fairly hardy thus far, and is perhaps the most attractive evergreen on our lawn. In its peculiar glaucous color it closely resembles the Colorado Blue Spruce, *Picea pungens*, but the greater compactness of its branches renders it decidedly more attractive than this species.

NOTES ON ORCHARD FRUITS.

E. S. GOFF

The last trees of the apple orchard formerly planted on our Experiment Station farm were removed in the fall of 1891, to make room for the new Dairy School building. The planting of fruit trees for a new orchard was commenced in 1889 and has been continued to the present time, more or less trees having been planted each spring.

The original orchard was of varieties then considered standard. The new orchard, which includes trees not only of the apple but also of the pear, plum and cherry, is being planted with varieties that are believed to be promising, but which have not thus far been sufficiently tested to warrant their general planting. Many of the apple and plum trees are propagated from "seedlings," i. e., from trees that have grown up from seed planted either intentionally or by chance, and which, after reaching bearing age, have proved hardy, productive and otherwise desirable. Many of the apple trees are from parents that have been standing for 20 to 40 years and have not only endured the winters, but have gained a local reputation for the value of their fruit. The effort has been constantly made to procure cions from such trees not only in our own state but also in Minnesota and Iowa. Our plan is to test these and to reject all that do not prove superior in hardiness, productiveness and quality as fast as their defects are discovered. All of the promising Russian varieties are also being tested, and attention is being given to seedlings of our own growing from seeds of known parentage.

Thus far trees of our new orchard, which is located on a north slope adjacent to the Horticultural building, have

borne so little that no report of them seemed called for. The past season, however, several of the plum trees and two of the apple trees yielded sufficient fruit to enable us to form some opinion as to their qualities. It is hoped that each succeeding year may bring others into fruit.

THE PLUM.

Of the plums, Forest Garden, De Soto. Le Duc, Moore's Arctic, Maquoketa, Ocheeda, Quaker, Pottawattamie, Rockford, Rollingstone, Smith's Red, Wyant, a so-called "Seedling from German Prune," and a "Seedling No. 3" bore full crops, many of them more than the trees could develop to full size. Mariana and Wild Goose yielded a fair crop, and the White Nicholas ripened a very few fruits.

The Mariana was the first to ripen, the fruit being at its best about August 13. Forest Garden, Pottawattamie, Le Duc, "Seedling from German Prune" and "Seedling No. 3" ripened about a week later, followed by Quaker, Smith's Red, Rollingstone, Wild Goose, Rockford, White Nicholas and Wyant in the latter part of August, and Moore's Arctic, Maquoketa, Ocheeda and De Soto in the first half of September.

Of the varieties named Moore's Arctic and White Nicholas are of the European class, *Prunus domestica*; the others belong to native species, and with the exception of the Pottowattamie, Wild Goose and Marianna,* all are probably *Prunus Americana.*

Of the native varieties the Rockford was pronounced the finest in quality. The fruit is rather large, slightly oblong, truncate at the base, with a distinct suture; skin purple, sometimes inclining to orange, often a little speckled, with a very thin bloom; stem half an inch long, slender and set in a decided cavity; flesh rich yellow, almost free from stone, tender, sweet and rich; skin thin and without acerbity; stone oval, bluntly pointed, very obscurely margined.

Scarcely second to the Rockford in quality was the Ocheeda of which the fruit was medium to large, nearly round, with

*The Pottawattamie is assigned by Prof. Bailey to *Prunus angustifolia*, the wild goose to *P. Hortulana* and the Mariana to *P. Myrobalana?*—Bulletin 38, Cornell University Agrl. Expt Station.

an obscure suture; dull, finely mottled red beneath a rather thick bloom; flesh yellow, sweet and rich, free from the oblong, strongly margined, smooth stone; skin medium in thickness, without acerbity.

Cions of this variety were sent to our Station in the spring of 1891 by Mr. J. S. Harris of La Crescent, Minn. It was originally found wild in Nobles Co., Minn., and was introduced by H. J. Ludlow of Worthington, Minn.

The "Seedling from German Prune" was received from S. D. Richardson & Son, of Winnebago City, Minn., in the fall of 1891. If the parentage of this plum is correctly given, it must certainly be a hybrid, for it possesses many *Americana* characteristics. The fruit is of large size, dull red, and densely dotted with minute yellowish specks. The flesh is tender, sweet and rich, but the skin is rather thick and has a somewhat harsh taste. I regard this plum as eminently worthy of further trial.

Smith's Red was received in the spring of 1890 from Mr. I. F. Gale of Waukesha, Wis. The fruit is large, nearly globular, purplish red, shading to orange on the more shaded side, with yellow, netted, sweet and tender, nearly free flesh and with a rather thick skin that leaves no unpleasant taste in the mouth. The stone is roundish and rough, but not margined. The fruit matured slowly and continued a long time in season. This variety is also well worthy of further trial.

The "Seedling No. 3," from same source as the last, had fruit of good size, roundish in form, rather strongly flattened, dull red, without specks, with a distinct suture, and very tender, sweet and pleasant flesh that was almost free from the oval, bluntly pointed, obscurely margined stone. The skin is very thin and nearly without acerbity. This was one of the finest eating plums I have tasted. The fruit would be too soft to ship well unless gathered before fully ripe.

The four varieties above described all seem to me to be superior to most of the older native varieties.

The White Nicholas is the first of the Russian varieties that has fruited at our Station. The fruit is medium to large, oblong, thickest near the stem, with a rather obscure

suture; very deep purple with thin bloom. The flesh is half tender, a little acid, not above fair in quality and clings to the large, ribbed stone. As noted elsewhere this variety blossomed full, but nearly all of the fruits dropped when very small.

Moore's Arctic is worthy of especial mention, for it was the only variety of the European plum, *Prunus domestica,* that bore a full crop, though we have trees of the Lombard, Green Gage and of several Russian varieties that are old enough to bear. As a rule, the European varieties not only did not fruit, but did not bloom, a significant fact, since it suggests that the flower buds were destroyed by cold. Moore's Arctic is of good size and of sufficiently fine quality to render it desirable either for home use or market.

With the exception of Wyant,* of which the fruit is too astringent to be desirable either raw or cooked, all the varieties named in our list as having borne full crops are well worthy of trial. Our experience with them is not as yet sufficiently long to warrant us in naming a select list either for home use or market.

The other varieties named have been well described in Prof. Bailey's Bulletin No. 38 of the Cornell University Experiment Station.

Our plums were protected from injury by the curculio, *Conotrachelus nenuphar*, by the so-called "jarring process," i. e., the insects were jarred from the tree in the early morning, upon a cloth-covered frame placed beneath the tree, and then killed by hand. The curculio was not numerous the past season and some trees not thus treated bore well, but as a rule the fruit of all plum trees in the vicinity of Madison is destroyed by this insect unless prevented by the jarring process. Our trees were treated for the first time on the morning of May 12, and every still morning threrafter when it did not rain or snow, until June 20. Nearly every morning when the trees were visited, during this period, more or less cur-

*I am in doubt as to the genuineness of our variety under this name, although trees of it procured from two different Iowa nurseries are unquestionably the same.

culio were found, one of the largest catches being on June 11. This fact is mentioned because the question is often asked, "How long is it necessary to continue the jarring process?" Probably the time was lengthened the past season by periods of cold wet weather, for it was observed that on such mornings very few curculio were found, but that the number would rapidly increase on the return of warm weather.

With the proper outfit and with a little experience in its use, the labor of jarring trees for the curculio is very slight, it being necessary to spend but a moment at each tree.

THE APPLE.

The varieties of the apple that have fruited thus far are the Hoadley, of which trees were receivd from Charles Hirschinger, of Baraboo, in 1890, and the Windsor Chief, of which trees were received from J. C. Plumb & Son of Milton, in the same year.

The Hoadley is a large apple of the Duchess type, quite similar to the Duchess in most respects, but maturing about a month later. The trees grow finely, bear young, and thus far appear perfectly hardy.

The Windsor Chief is a medium to large apple; oblate, inclining to conic, with a dull yellow ground mostly obscured with very dull red, and sprinkled with conspicuous yellow dots. The flesh is white, half tender, with a rather rich and pleasant sub-acid flavor. The fruit keeps well until March. The tree grows well and has not suffered from cold, but showed some inclination to blight the past season.

FLOWERING AND FERTILIZATION OF NATIVE PLUMS.

The uncertain fruitage of the native plum is well known. The past season a somewhat careful study was made of the flowers of the varieties of plum growing at the Wisconsin Experiment Station, in the hope of discovering some of the reasons for the frequent failure of the blossoms to produce fruit.

Of the plums of which the blossoms were examined—34 varieties—it was observed that the varieties belonging to native species have decidedly more slender styles and smaller stigmas than those of the European plum—*Prunus domestica*, and the slender styles of the native species were more often broken or bent by driving rain than those of the *domestica* varieties examined. A severe rain storm during full bloom would doubtless prove much more harmful to the native than to the European varieties.

All of the varieties of plum that bloomed at our Station the past season appeared to produce abundant pollen. When we consider that all the anthers of the same flower rarely mature at the same time, and that the flowers on a given tree usually have a range of some days in their time of opening, it seems improbable that, where abundant pollen is produced, a total failure in pollenation could result, even in unfavorable weather. A rain storm occurring when the trees are in full bloom, if not sufficiently severe to destroy the pistils would probably promote pollination, since the rain tends to dislocate the stamens and often leaves the anthers in direct contact with the stigma.

Imperfect pistils or an absence of pistils has been suggested as a reason for infertility in the native plums. Unquestionably this defect sometimes occurs. Careful observations on this point were made in our Station plum trees the past season and a marked difference was found in the percentage of perfect pistils in the different varieties. The results of these observations are tabulated below:

Variety.	Number of flowers examined.	Number of perfect pistils.	Number of flowers without pistils.	Number of abortive pistils.	Number of pistils that had been destroyed.	Per cent. of perfect pistils.
De Soto	116	107	1	3	5	92
Forest Garden	109	106	0	0	3	97
Forest Rose	118	108	0	2	3	95
Homestead	59	49	9	1	0	81
Le Duc	116	87	5	12	12	75
Maquoketa	134	127	2	1	4	95
Mariana	247	154	62	20	11	62
Miner	105	101	1	0	3	96
Moore's Arctic	127	121	3	1	2	95
Moreman	104	30	73	1	0	29
Ocheeda	113	104	3	4	2	92
Pottawattamie	104	100	0	3	1	96
Quaker	106	100	2	3	1	94
Robinson	104	65	37	1	1	62 5
Seedling from German Prune.	101	84	1	8	8	83
Seedling, No. 3, Gale	105	87	8	9	1	83
Seedling from Sparta	103	72	4	18	12	68
Smith's Red	122	112	3	3	4	92
White Nicholas	100	100	0	0	0	100
Wild Goose	123	76	35	....	12	62
Wolf	103	98	10	0	0	91
Wyant	115	97	15	3	0	84

It appears that the percentage of perfect pistils varied from 29 in the Moreman plum to 100 in the White Nicholas. The effort was made to ascertain if the proportion of flowers that formed fruits in the different varieties corresponded with the percentage of perfect flowers. Immediately after the falling of the petals such a correspondence was apparent, but after the miniature plums had grown to the size of an apple seed, or a little larger, a large proportion of them dropped from the trees of some varieties that had shown a high percentage of perfect flowers, indicating that some other influence had affected the fertilization beside the question of perfect pistils. A cold period occurred about this time, and it is possible, as

Mr. R. P. Speer has suggested,* the low temperature prevented the formation of the pollen tube. The dropping of the miniature fruits was sometimes most marked in the varieties that apparently possessed the most robust pistils. The White Nicholas, a Russian variety of the *domestica* species, was the only one examined that had 100 per cent. of perfect pistils, and the styles and stigmas of this variety were especially large, yet while the tree blossomed full, but two or three fruits grew to maturity.

These observations indicate that the failure of blossoms to set fruit in our native plums is probably due to more than one cause, and that while they do not show that the failure is never due to a lack of pollen it seems probable that it more often results from a deficiency of pistils or from cold weather during the period of fertilization. In the cases under consideration, the inability of certain varieties to fertilize themselves could hardly have prevented fruitage, since the trees were closely planted and each variety had trees of several other varieties in the near vicinity.

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* Bulletin No 4 Iowa Agricultural Experiment Station.

EXPERIMENTS IN THE CURING AND CULTURE OF TOBACCO.

E. S. GOFF.

During the winter of 1892-3 the legislature of Wisconsin made a special appropriation of eight hundred dollars for two years, to be used at the Wisconsin Experiment Station for experiments in the culture and curing of tobacco. Accordingly in the spring of 1893, a series of experiments was planned and a small field of tobacco, amounting to about one and a half acres was planted. During the summer a small curing-house (28 by 32 feet), designed especially to facilitate investigation in the curing of the crop, was erected, in which the tobacco was hung and cured. The past season, (1994) a crop was also grown and cured—the area being a trifle larger than that of the previous season.

The curing house was divided by matched board partitions into four compartments of nearly equal size, and a hall was constructed from a door in one end of the building to the center, where a stairway, with several doors opening into the different compartments, permitted easy access to the tobacco hanging in the different tiers in each compartment. The building was inclosed with close fitted, drop sliding, and each compartment was provided with ventilating doors, and a central roof ventilator so arranged that it could be opened and closed at will. Provision was also made for placing a lighted lamp in each roof ventilator in order to promote an upward current of air when this appeared desirable. and the past season, additional means for promoting ventilation by means of heating flues was provided, the details of which will be described further on.

A report is here offered of certain investigations of which

the results appear to be well defined. Some experiments with fertilizers were commenced the past season but the report on these will be deferred until further data are secured.

EXPERIMENTS IN THE CURING OF TOBACCO.

The curing of tobacco as practiced in the northern states does not appear to have been made the subject of careful investigation. Certain more or less crude ideas upon the subject obtain among tobacco growers, but the more intelligent and thoughtful ones are usually most conscious of the meagerness of their knowledge. It is hardly an exaggeration to say that the tobacco crop of the average grower is as much at the mercy of the weather after it is hung in the curing-house as while it was standing in the field. Through ignorance of the requirements, the lack of proper appliances, or the slack application of the means at hand, the crop is usually permitted to cure too fast or too slow, according as the weather chances to be too dry or too wet, to produce the best quality. Yet those best informed agree that much of the quality of tobacco is made or unmade in the curing-house, and that Wisconsin tobacco grown and cured under the most favorable climatic conditions, compares well in quality with the best samples of Eastern tobacco. It has seemed wise, therefore, to devote a part of our first efforts to an investigation of the curing process.

Changes during the curing process.—The most conspicuous changes that occur in the curing of tobacco are a decided loss in weight, due mainly to evaporation of water from the leaves, and a change of color in the leaves from green to varying shades of brown. Various chemical changes also occur that materially alter the properties of the leaf, but as these belong to the field of the chemist they will not be here considered.

The amount of water evaporated during curing.—On this point we have the following data.

The plants were weighed in the field after having wilted somewhat, and the stalks and cured leaf were again weighed after stripping.

Year.	Number of plants.	Treatment during growth.	Weight green.	Weight cured.	Per cent. of loss in curing.
1893	100	Not irrigated.....	199.25	57.8	70.
1893	100	Irrigated.........	245.75	71.5	71.
1894	....	....	3,320.45	960 8	71.

From the above data it appears that under our conditions the loss in weight during curing was about 71 per cent. of the weight of the green plants. In other words of each ton of green tobacco hung in the curing house about 1400 lbs. were water that was given off during the curing process. A small part of this loss in weight may have resulted from chemical changes, but, on the other hand, some loss took place during the wilting of the plants previous to the weighing.

Conditions affecting the escape of water from curing tobacco.—It would seem natural at first thought to suppose that this very large loss of water from the leaves would proceed fastest in the green tobacco, and that the rate would gradually diminish until the leaves were entirely cured, the rate at all times being much dependent upon the weather. But from many observations made during the season of 1893, I was led to believe that other causes connected with the changes going on within the leaves interfere to modify this seemingly natural law, an opinion which I was able to demonstrate during the past season. Circular discs were cut between the veins of leaves of tobacco in different stages of curing, which, after being weighed upon a chemical balance, were exposed for a given length of time to the air of a closed room, when they were again weighed and the loss in weight that had occurred during the exposure determined. The discs were cut to a uniform size with the sharpened end of a metal tube, the leaf being placed over a large piece of cork. As fast as the discs were cut, each was placed between two watch-glasses that were ground so as to fit tightly together, and the watch-glasses were placed beneath a bell-glass that

rested on a closely fitting ground glass plate. The discs were weighed between the watch-glasses, and not until they were all weighed were they uncovered to the air. Five duplicate trials were made, of which the numerical data are preserved. The average amounts of evaporation from the different samples are shown comparatively in the accompanying diagram.

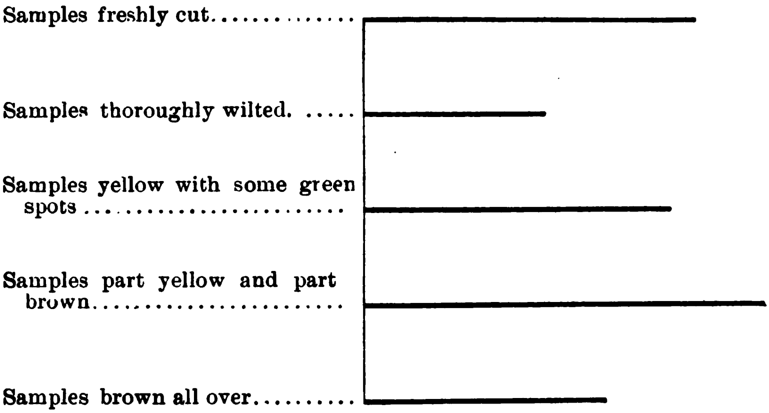

FIG. 51—Showing comparative rate of escape of water from tobacco leaves in different stages of curing.

From the above diagram it appears that the period of most rapid escape of water from curing tobacco is in the browning stage, i. e., while the color is changing from yellow to brown, and that with tobacco that is well wilted at the time it is hung, the escape of water from the leaves is at first comparatively slow. This furnishes a warrant for the practice of many intelligent tobacco growers who hold that it is better to keep the curing-house nearly closed for a time after the tobacco is hung, and that it should be gradually opened as the curing proceeds. It is well known also, that the danger from the affection of curing tobacco known as "pole-burn" is greatest not immediately after the tobacco is hung, but several days thereafter, a fact that is, in part at least, explained by the results of this experiment.

The changes in color of tobacco leaves while curing are not due directly to the loss of moisture. That this is true was shown by placing tobacco leaves beneath a bell glass that

set upon a ground glass plate and in which the air was kept nearly saturated by the moisture that escaped from the leaves. The leaves assumed first a yellow color, and afterward changed to brown in about the same time as other leaves that were curing in the ordinary manner. After assuming the brown color under the bell glass, the leaves still contained so much water that the liquid could be readily expressed by squeezing them in the hand. It is well known that in curing tobacco by artificial heat a given color can be fixed at any time by a rapid drying of the leaf, showing that the changes of color are not the result of drying.

The particular shade of brown assumed by cured tobacco leaves depends much upon the degree of ripeness to which the leaves attain before cutting, as was conclusively shown by repeated experiments. The riper the tobacco the lighter shade of brown will the cured leaf have, and leaves that become spotted with yellow before cutting will produce a cured leaf that is mottled with varying shades of brown. The lower leaves on the plant usually cure lighter than the upper ones, because they are riper. I mention these facts not because they are new to all tobacco growers, but because I have demonstrated them during the past two seasons by careful and repeated observation. I incline to think, also, that tobacco cured early in the season, as in August, while the weather is warm, is usually of a lighter shade of brown than equally ripe tobacco cured later in the season, while the weather is cooler and the days shorter. A knowledge of the relation between the maturity of tobacco and the shade of brown assumed by the cured product is valuable, because it enables us to produce the shade of color that the market demands.

The degree of atmospheric moisture best suited to the curing of tobacco.—It is universally admitted that tobacco may dry both too fast and too slow to yield the best quality of cured leaf, but so far as I know, no one has attempted to define the range within which the best quality is produced. Tobacco growers and packers agree that the finest samples of tobacco are usually found in crops that are more or less damaged by pole-burn, a disease resulting, indirectly, from

too slow drying; and that in seasons when pole-burn is prevalent, the quality of the tobacco that escapes damage from the disease is generally good. From this we infer that tobacco should dry slowly to yield the best quality of cured leaf, but of course the rate of drying should not be so slow as to induce pole-burn.

The attempt has been made during the past two seasons to determine the highest degree of atmospheric moisture that may be maintained within the curing house and still avoid damage from pole-burn, for in the present state of our knowledge this would seem to be the point at which to aim. While much still remains to be done, it is thought that sufficient has been accomplished in this line to merit presentation, and that the hints here offered may be turned to practical use by tobacco growers.

The investigation has been carried on in a special apparatus in which the temperature and moisture of the air could be kept nearly uniform, and, at the same time, careful observations were made in the curing-house itself. The apparatus consisted of a chamber, eighteen inches in each dimension, inclosed on five of the six sides by double walls of sheet copper between which water from a hydrant constantly flowed, and, in addition, the whole was surrounded with a double walled wood case having a door on the side not inclosed by the copper jacket. Thus the chamber was maintained nearly at the temperature of the hydrant water of which the fluctuations in temperature were not very great. Ventilation of the chamber was accomplished by connecting a small laboratory air-pump, operated by water from the hydrant, with an opening through the wall at one side near the bottom, and a corresponding opening was provided on the opposite side of the chamber near the top, to admit fresh air from without. The door of the chamber contained a window formed of two thicknesses of glass with an air chamber between, so that a psychrometer hanging within could be read without opening the door. It was found on trial that the air-pump did not change the air within the chamber sufficiently fast to prevent it from becoming practically sat-

urated with moisture when green tobacco leaves were hung in the chamber, hence a fruit jar, filled with ice and setting in a tin cup, was kept in the chamber during the day, to condense the excessive moisture which was removed by emptying the cup from time to time. The temperature and humidity of the chamber as indicated by the psychrometer were noted several times each day, and the tobacco leaves were weighed daily to determine their loss of moisture. Notes were also made of their progress in curing. Thus, for the tobacco cured within this chamber, we have a nearly complete psychrometer record of the temperature and humidity of the air in which the curing took place.

We were enabled to complete the curing of two successive lots of tobacco leaves in this chamber; the first lot was put in August 25, 1894, and the curing was completed, except the leaf stems, by September 11, when the second lot was put in, and which was well cured by October 2. Two samples were cured in each lot, one of well ripened tobacco and the other of that which was quite immature, and ten average leaves were used for each sample.

The results of this study are striking, since they indicate how great may be the humidity of the air in which tobacco cures without causing damage from pole-burn, and also indicate with some degree of clearness the maximum humidity that the tobacco can endure without damage from this affection. The numerical data connected with the experiment are too voluminous for presentation, but the diagram (Fig. 53) will convey an idea of the moisture of the air within the chamber during these trials.

It will be well here to explain the psychrometer, one form of which is illustrated on the following page, and th manner in which it is used. The instrument consists of two accurately graduated thermometers, of which the bulbs are placed at some distance apart, and of which the bulb of one is surrounded by thin muslin, which is connected by a wick of clean cotton to a cup hung a short distance below and which, while the instrument is in use, should contain more or less of distilled or clean rain water. The water from this cup

is drawn upward through the wick to the muslin that surrounds one of the bulbs, and thus the surface of this bulb is kept constantly moist, while that of the other bulb is dry.

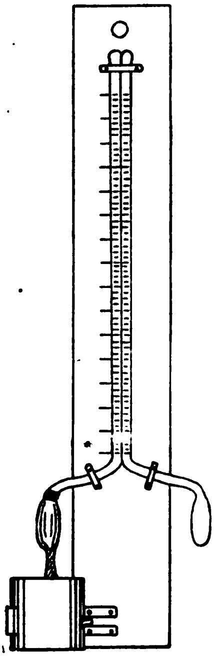

FIG. 52—A psychrometer, an instrument which indicates the temperature and moisture contents of the air.

Now the water on the surface of this wet bulb will evaporate into the air about it more or less rapidly according as the air already contains more or less of moisture,—the more moisture the air contains the less rapid will be the evaporation and vice versa. Since water in evaporating absorbs heat, the temperature of the wet bulb is lowered more or less, according as the evaporation is more or less rapid. Hence, by noting the difference in the temperature registered by the two thermometers we form an idea of the moisture of the air —the greater the difference registered the drier the air and vice-versa. When the two thermometers register alike the air in contact with the wet bulb is saturated with moisture, so that it can hold no more and hence evaporation has ceased. In dry summer weather the difference registered by the two

thermometers may amount to fifteen or more degrees. By using prepared tables the absolute relative humidity of the air may be determined by the psychrometer, but for our present purpose, the depression of the wet bulb is all that it is necessary to use. The tobacco leaves while in process of curing being moist, the evaporation from them will follow the same law as from the wet bulb, hence a psychrometer hung among the plants in the curing-house will give an indication at any time of the rate at which the moisture is passing off from the tobacco.

In the following diagrams (Figs. 53, 54) the average of the readings of the wet and dry bulb within the curing chamber already described are given for each day during the two trials. The temperature indicated in the diagrams are the average of all the readings noted for each day. The readings were generally made hourly from 7 a. m. to 6 p. m., though some omissions occurred.

In all diagrams given in this connection the zigzag lines indicate the fluctuations of the temperature as indicated by the psychrometer, the upper zigzag line being the record for the dry bulb thermometer, and the lower one for the wet bulb thermometer. Each straight horizontal line marks a degree in temperature the figures for which are given at the left, and each vertical line represents one day. The nearer the zigzag lines are together on any given vertical mark the more nearly was the air saturated with water on that day, and vice versa.

As appears from Figs. 53 and 54, the air within the chamber was decidedly moist during both trials, the depression of the wet bulb rarely exceeding two degrees, and it should be understood that this moisture came from the tobacco leaves within the chamber.

In the first trial, as appears from Fig. 53, from August 26 to September 1 the air in the chamber was more nearly saturated than afterward. This was before the can of ice, already spoken of, was introduced. The ice was used to condense the excessive moisture because without it the air could not absorb the water as rapidly as it was being set free from

the leaves, hence the latter were becoming soggy and apparently saturated with water in places. After the ice was introduced these soggy spots ceased to increase in size, though some days were required for the air to catch up, so to speak,

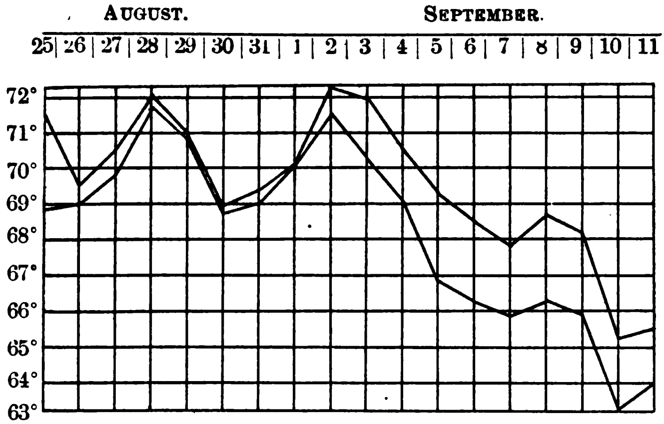

FIG. 53—Showing range of temperature and wet bulb depression in first incubator trial. The upper zigzag line shows the temperature of the dry bulb, and the lower that of the wet bulb.

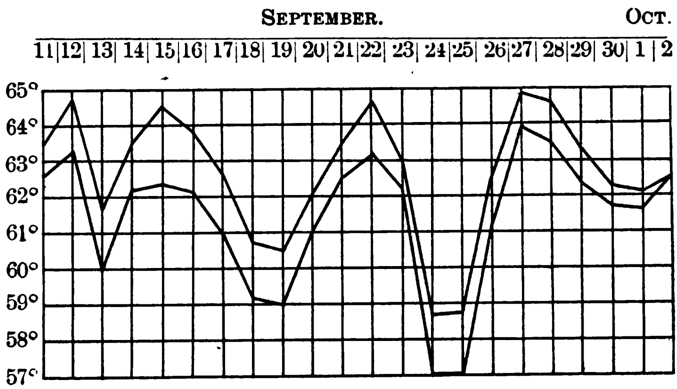

FIG. 54—Showing range of temperature and wet bulb depression in second incubator trial. The upper zigzag line shows the temperature of the dry bulb, and the lower that of the wet bulb.

with the water that was being given off from the leaves. In the meantime pole-burn set in, and the structure of the more soggy parts of the leaves was destroyed, while the parts that

did not become soggy cured out of fair quality. But all of the leaves showed more or less of the peculiar pimpled appearance that always accompanies pole-burned tobacco, and which, as I have now learned, is due to the moisture having not been absorbed from the leaf as rapidly as it was set free. In the second lot, which cured in a somewhat lower temperature than the first, and in an atmosphere not quite so highly charged with moisture, as appears from Fig. 54, no pole-burn appeared, though the pimpled appearance was manifest more or less on nearly all of the leaves.

It is of interest that the more unripe samples of tobacco in both trials were less affected with pole-burn, and showed less of the pimpled appearance than the riper ones.

The diagrams here shown are worthy of careful study, because they indicate rather clearly the range of humidity within which danger of pole-burn lies. From Fig. 53 it appears that from August 26 to September 1, the wet bulb depression was less than one degree, after this date it varied from one and a half to two and a half degrees. Prior to September 1st the tobacco leaves that had reached the browning stage became soggy and pole-burn set in. After this date the excess of water and also the pole-burn disappeared. From Fig. 54 it is seen that the wet bulb depression varied from one to two degrees, except in a few instances when it was slightly less than one degree. No pole-burn appeared in this lot of tobacco, but the leaves became somewhat soggy at times. In Fig. 55 is shown the range of temperatures * in one compartment of the curing house in which the tobacco was hung very thickly—four laths to the foot and six plants to the lath.

As appears, the wet bulb depression rarely exceeded one degree, and was often less. Pole-burn was detected in this compartment on August 30, and despite the fact that artificial heat was frequently used to promote ventilation, the

*The psychrometer readings in the curing house were taken daily at 7 a.m. 12 m. and 6 p. m. and the temperatures recorded in Figs. 55 and 56 are the average of the three daily readings. The psychrometers hung between, and about eighteen inches below, two laths on the second tier.

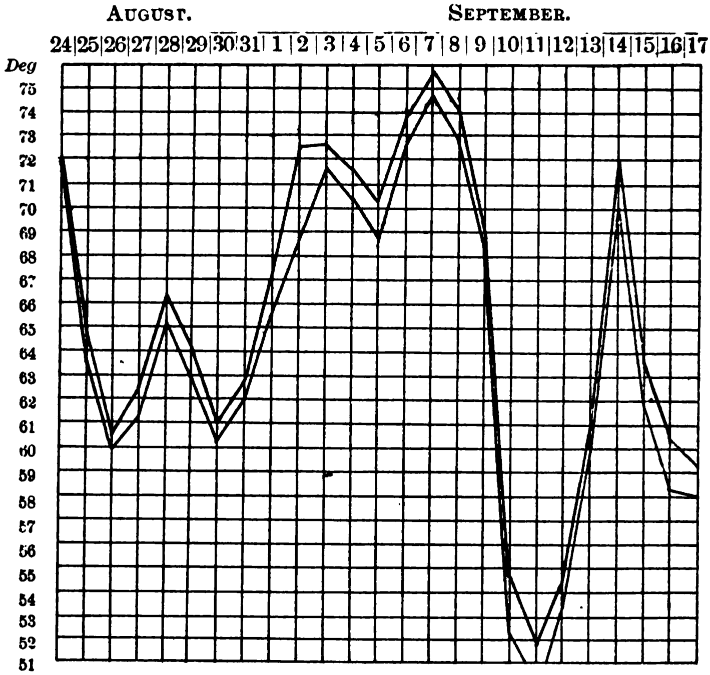

FIG. 55—Showing range of temperature and wet bulb depression in a compartment where tobacco was hung too thickly.

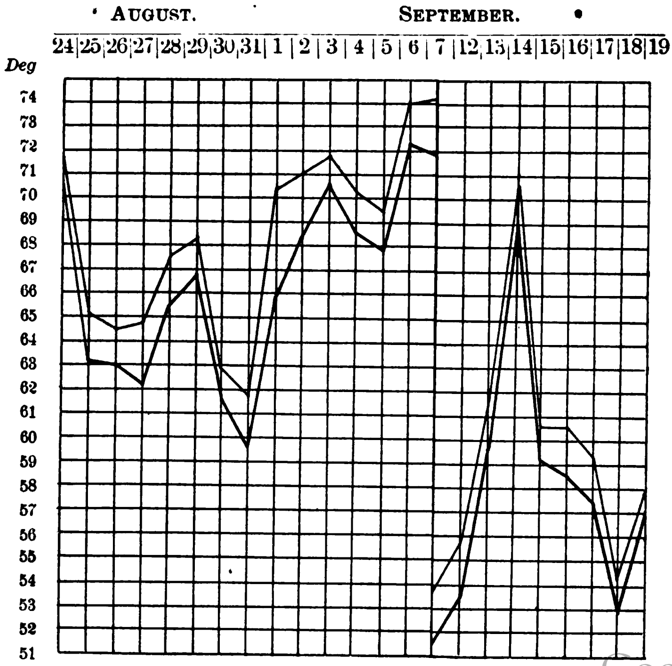

FIG. 56—Showing range of temperature and wet bulb depression in a compartment that was well ventilated. [Record omitted from September 7 to 11.]

tobacco was badly damaged, not less than 56 per cent. of the eaves being affected. In Fig. 56 we have the range of temperatures in another compartment of the curing house in which the laths were placed five inches apart. It is seen that the range differs little from that of Fig. 28 except in the fact that the wet bulb depression was in no case less than one degree, and was generally from one and a half to two degrees. In this compartment no symptoms of pole-burn appeared at any time and no pole-burned tobacco was found. The tobacco in this compartment cured out of excellent quality. In a third compartment, in which part of the laths were placed five inches apart, the wet bulb depression was maintained by careful attention to the ventilation as nearly as possible at two degrees, except for a period of four days, when the ventilators were intentionally closed to produce pole-burn. But only at the close of this four day period, and after the wet bulb depression had been reduced to zero, were symptoms of pole-burn manifest in this room. They soon disappeared on the restoration of the two degrees depression, and the tobacco contained but a minimum of damage from pole-burn.

From these data the conclusion seems warrantable, that with a temperature within the curing house of not exceeding 75° F., a degree of atmospheric humidity represented by a wet bulb depression of two degrees, when the psychrometer is between the plants, and is not exposed to unusual air currents, does not endanger the tobacco to pole-burn, and that an occasional variation to one degree is safe at least, if not prolonged. But a wet bulb depression of less than one degree is dangerous, and if prolonged, is almost sure to result in pole-burn.

The curing of tobacco is probably rather a process of elimination of water than one of drying.—This was shown by the fact that in the trials within the chamber already described, the leaves set free their water so fast that the air in the chamber could not absorb it all, and the leaves became soggy in places. It was also shown when green tobacco leaves were placed under a bell glass. The leaves threw off their mois-

ture until the air within the bell glass became saturated as was shown by a copious condensation on the inner surface of the glass. But the elimination of water did not stop here. As portions of the leaves commenced to pass from the yellow to the brown stage these parts became so wet that water could be readily expressed from them by squeezing in the hand. This is what occurs in the curing-house when insufficient ventilation is given during the browning stage, or when the tobacco is hung too thickly rendering sufficient ventilation impossible. The air confined between the plants becomes so charged with water that it can take no more, when the liquid gathers in minute drops on the surface of the leaves. I have never known this excess of water to occur until the leaves have reached, or were approaching the browning stage. We are now ready to consider in more detail the subject of

Pole-burn in tobacco.—This affection is the indirect result of the leaves becoming moistened by this excess of water which furnishes the necessary conditions for the germination of the spores of the microscopic organism or organisms that cause the disease. It is a decay of the leaf, resulting from a too prolonged exposure to the excess of water. All parts of any given leaf rarely, if ever, reach the browning stage at the same time, which explains the fact that pole-burn, in cases of slight affection, is found distributed over the leaves in such apparent irregularity. Spots of it appear here and there, without any apparent order of distribution. When the atmospheric conditions favor pole-burn the parts of the leaves that are in the browning stage are affected, while the parts that have not yet reached this stage, or have passed it to a sufficient degree, escape. The wet, oily appearance of the leaf may be regarded as the first symptom of pole-burn. Later a characteristic odor is given off. The destruction or weakening of the tissues is not always apparent until some time after the oily appearance has been assumed.

I do not here attempt to consider the specific organism or organisms, if such there be, that are the direct cause of pole-burn, which belongs to the field of the mycologist. If it is

due to a specific organism it appears that its spores are practically omnipresent, for it seems certain that under the proper conditions all tobacco that has not been sterilized is affected by pole-burn.

I had formerly supposed that the wet condition of the leaf accompanying pole-burn was caused by condensation of moisture from the air, due to lowering of temperature, but I found no evidence either during the past season or during the summer of 1893 to corroborate this opinion. I failed to find a single instance where the water so apparent in the leaves affected with pole-burn appeared to have come from the air. Had it come from condensation, something analogous to dew would have occurred in the curing-house during cool nights, and the moisture would have been noticeable on the outer leaves of the plant as well as upon the laths and the timbers of the building. But no such conditions were observed. The wet leaves were almost always those that were more or less covered by others.

How to prevent pole-burn.—From what has been said, it is clear that the preventive of pole-burn is to provide sufficient ventilation in the curing-house so that the air in contact with the leaves does not become so nearly saturated with moisture that it can no longer take up the water given off by the leaves. Here the value of the psychrometer appears. By having one of these instruments hanging between the plants in a central part of the curing-house we have only to note the depression of the wet bulb to discover at once if danger from pole-burn approaches. It is not safe to wait for the moisture to appear on the surface of the leaves nor for the characteristic odor of pole-burn, for then the trouble has already commenced and much damage may result before it can be checked.

Ventilation of the curing-house.—As has already been stated, the best quality of cured tobacco is generally found in crops that are more or less damaged by pole-burn and that the point at which to aim is slow curing, but not so slow as to induce pole-burn. It is clear that in a climate so variable

as that of Wisconsin, the ideal curing-house must be made sufficiently tight to shut out, in a measure, the hot and dry air that so often prevails in August and September, to prevent the tobacco from curing too fast; and it must also have a provision to use artificial heat to produce a less humid air within the house in case of a warm and wet period of weather at the critical stage of the curing process. In our experimental curing-house we have provided for emergencies both in the direction of dry and wet weather;—for dry weather, by inclosing the building with closely fitted drop siding with tight fitting doors, which gives almost complete control over the amount of air that enters the building; and for wet weather by placing a small box stove in each compartment from which a long pipe extends nearly horizontally about three sides of the room, near the ground, passing out through the fourth side a sufficient distance for safety, and then extending vertically for a few feet. The system is illustrated in Fig. 57. An excavation, A, was made beneath the sill of the building at one side of the room, sufficiently long and wide to admit the stove, B, which extends into the room as indicated, and to provide space in front of the stove for putting in wood, etc., and sufficiently deep so that the top of the stove was a foot or more below the bottom of the sill. The space between the stove and sill, and between the stove and the earth walls of the excavation was bricked up with hollow building tiles, which admitted air freely to the room, at the sides of, and over the stove. Common brick might have been used for this purpose. The pipe, C, eft the stove at the level of the ground floor of the room, and rose gradually in its course, being supported upon bricks and passing out at D above the sill, through a double-walled tin cylinder. As the rooms in our curing-house are all small —the largest being but 16x28 feet—a small stove, carrying a six inch pipe, answered the purpose. No difficulty was experienced in securing a good draft, and, except in one room, in which the tobacco was hung too thickly (four laths to the foot), the humidity of the air within was found to respond

readily to the heat from the stoves, even when a very little fire was used. After the curing was completed the pipes were taken down and stored for use next year.

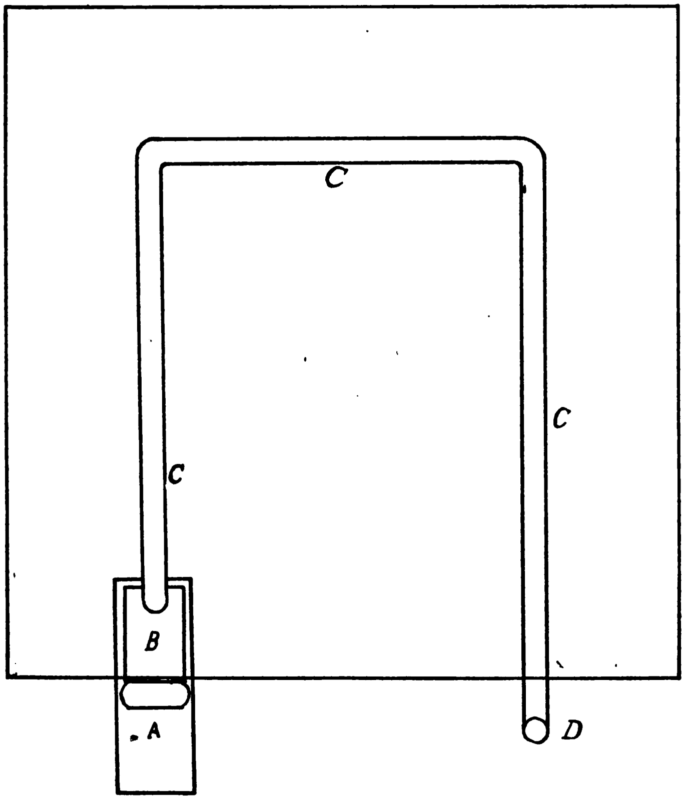

FIG. 57.—Showing location of stove and heat-flue in experimental curing house.

From the experience of the past season I think that a curing-house one hundred feet long could be sufficiently warmed by means of four thirty-six inch box stoves, carrying seven inch pipe, placed as shown in Fig. 58. The stoves should be let into the ground beneath the sills and bricked in as above described. The pipes should start at the ground level and rise eight or ten inches to the rod. If they come in the way of hanging tobacco, remove a sufficient number of plants to make room. They may be supported on temporary brick piers, or suspended by wires from the scantling that carry the tobacco. The portion of the pipes extending outside of

the building will be more durable if made of galvanized iron, and should be capped with spark arresters, but the remainder may be of common sheet iron.

The pits in which the stoves are located should have their sides planked or bricked up, and be provided with plank covers, and eve-troughs should be placed above them to keep out water.

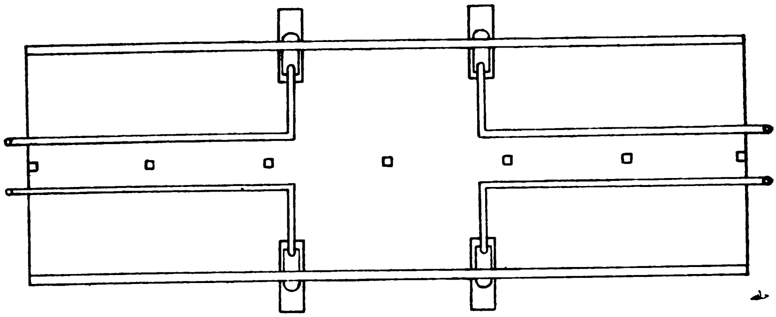

FIG. 53—Showing method of using artificial heat for ventilation in a large curing house

The first cost of such a heating system need not much exceed seventy-five dollars, and as it would not be used much in any one season, if the pipes were properly stored when not in use, it would last many years.

The increased value of a single crop of tobacco saved from a severe attack of pole-burn by such a heating system would be more than sufficient to pay for its cost, and if by providing it as a safeguard, the crop may be caused to cure slowly as it should, in dry seasons, the apparatus may be made t pay for itself nearly every year. I may add that with the heating apparatus, the tobacco may be hung a little closer than would otherwise be prudent, thus permitting a somewhat smaller building for a given acreage.

In constructing a curing-house with the intention of providing such a heating apparatus it would be well to build it two feet higher than the needs of the tobacco alone would require, to provide more room for the pipes beneath the lower tier.

I am fully aware that the recommendation to equip a tobacco house with heating apparatus will be regarded as

foolishness by some Wisconsin tobacco growers, who now attempt to cure their tobacco in the poorest building on the farm, and who have been accustomed to regard any structure sufficiently inclosed to keep out stock as a fit place for curing what should be their most valuable crop. Nevertheless I affirm with entire confidence that the tobacco crop cannot be so cured as to yield the best possible quality every year without a building in which the humidity of the atmosphere is under control, and without the requisite knowledge and attention in the use of such a building. And I am equally confident that the market value of the crop will be sufficiently enhanced by providing these requirements to abundantly repay their slight additional cost.

Moist air is lighter than drier air at a given temperature and hence tends to rise. Comparatively dry air entering the curing-house near the ground and coming in contact with tobacco that is giving off moisture, as it absorbs this water will gradually rise through the building, absorbing more and more moisture in its course until it reaches the roof. It is important, therefore, not only that the curing-house shall contain ventilators through the roof or in the gables, but that these be so made that they can be opened and closed at will, because these furnish an efficient means for controlling the humidity, providing the weather boarding of the building is tight, as it should be. In ordinary weather, it is probably better to use only the ventilating doors near the ground, and the roof ventilators, leaving the higher side doors closed except as an emergency seems to require special ventilation, and the control may be mainly exercised by the roof ventilators, since by opening or closing these more or less, the air as it rises between the hanging tobacco plants may be compelled to rise more or less rapidly as seems desirable. But it should be remembered that when the external air is very moist, as in rainy weather, this upward current of air will largely cease because the absorption of water from the tobacco will be greatly checked. At such times the temperature of the air between the plants must be raised to restore normal absorption, and the only way to do this is to provide

artificial heat. Placing lighted lamps beneath the roof ventilators will help to produce an upward current of air, as was proved in our experiments, but this will not avail to prevent pole-burn if the air that enters the building is already on the verge of saturation.

It is important that the plants in the curing-house be hung, so far as possible, at uniform distances apart, and when hung on laths, the end plants on the laths should be hung sufficiently near to the ends of the laths so that when the laths are placed in position, open spaces are not left where the ends of the laths of adjacent courses come together, thus forming chimneys for the ascent of the air. Otherwise, the air may be able to rise through these open spaces as rapidly as it can make its exit through the roof ventilators, and thus the more confined air between the laths be greatly hindered in its ascent. The existence of such currents through these open spaces was demonstrated in our own curing-house by placing one psychrometer between the laths at the center, and a second at the ends, when it appeared that the latter instrument registered a lower wet bulb depression than the former, indicating a less humid air.

In our trials it was found that laths containing six medium plants placed four and five inches apart respectively, cured well without pole-burn, while laths placed three inches apart gave considerable pole-burned tobacco in spite of the fact that artificial heat was used.

SUMMARY OF THE PRECEDING ARTICLE.

Green tobacco loses in round numbers about 71 per cent. of its weight during the curing process.

The rate at which the water passes off gradually increases from the time the leaves are well wilted until they assume the brown color. The water appears to be set free by the leaves rather than extracted from them by drying.

The changes in color of tobacco leaves during the curing process are not the result of drying but of certain changes within the leaves themselves. Riper tobacco yields a lighter color of cured leaf than that which is less mature.

In curing tobacco the aim should be to have it cure in as moist an atmosphere as possible without incurring damage from pole-burn.

The psychrometer is a very useful instrument in the curing of tobacco because it enables us to anticipate danger from pole-burn. A wet bulb depression of not less than one degree nor more than two degrees should be maintained by careful attention to ventilation.

The curing-house should be inclosed in such a manner that the amount of external air that enters it is under control and should be provided with some kind of heating apparatus that renders it possible to reduce the humidity of the air in wet weather.

The plants should be hung at uniform distances in the curing house, and so distributed as not to leave open spaces from the bottom of the building to the top.

FIELD EXPERIMENTS WITH TOBACCO.

E. S. GOFF.

Our tobacco was grown on a rather light clay loam, abundantly fertilized with composted stable manure, and the ground was plowed both in the fall and spring. The variety of tobacco grown was the so-called Wilson's Hybrid, of which seed was procured from Knoxville, Tioga Co., Pa.

AN EXPERIMENT IN THE IRRIGATION OF TOBACCO.

During the past two seasons, in both of which the summer has been exceptionally dry, the experiment has been made of irrigating a small plat of tobacco to see how far, if at all, this treatment would enhance the yield and quality.

In 1893 the part of the crop selected for this experiment was the latest setting, made July 6, at which date the soil was abundantly moist, but little rain fell thereafter until the tobacco had been harvested.

The first irrigation was made July 27. The plants at the time were suffering for water, as was shown by the wilting of the leaves during the warmer part of the day. Sufficient water was added to saturate the ground as deep as the plow line, the liquid being pumped from the adjacent lake by means of a rotary pump operated by a portable engine, and delivered over the plat through gas pipe supplemented by wood flumes. The effect of the irrigation was quickly noticeable upon the foliage, the leaves soon standing more upright; later the upper leaves on the irrigated part showed a disposition to spread more than those on the part not irrigated, and the color of the foliage became darker. A light shower the day following the irrigation very soon dried off from the portion of the field not irrigated, so that its effect was scarcely visible, but the

irrigated part retained its moist appearance upon the surface for many days. As soon as the surface became sufficiently dry, the irrigated plat was thoroughly cultivated, and as no rain came, irrigation was repeated on August 8th, as before.

From the date of the first irrigation until the cutting of the tobacco (Sept. 8), the effect of the irrigation gradually became more apparent through the increased growth in the irrigated part. After the plants were topped, the spaces between the rows on the irrigated part were noticeably narrower, and the upper leaves were decidedly broader and more spreading. At the time of cutting, one hundred average plants from the irrigated part, and the same number from the part not irrigated, were weighed, after which the two lots of plants were hung side by side in the curing-house. They were taken down December 15, stripped and the leaves and stalks weighed December 16. The data are given in the following.

Table showing effects of irrigation on product of green and cured tobacco.

	Weight green.	Weight of cured leaves.	Weight of stalks.	Weight of 100 av. leaves.	Area per pound of cured leaf.
	lbs.	lbs.	lbs.	lbs.	sq. ft.
One hundred plants irrigated..	215¾	23.15	48.9	8.84	52.44
One hundred plants not irrigated.....	199¼	22.11	35.9	7 88	49.00
Gain, presumably due to irrigation.......	46⅛	.04	13.0	.96	3.44
Per cent. of gain......	23.+	.. ..	33.+	13.01	7.02

The past season (1894) but one irrigation was given. This was made July 14, on a plat of tobacco of which the plants were set June 1st and which were forming the flower stalk at the time of the irrigation. The work was performed in the same manner as in the preceding year, the whole ground being soaked with water as deep as the plow line.

The plants on the irrigated plat, and on adjoining plat not irrigated, were topped July 17, and at this date—but three days after the irrigation—the effect of the water was readily visible by the lighter green of the leaves on the irrigated plat, and by the fact that the tops broke off much easier on this

plat than on the other. A hard wind-storm, which came about this time, broke down the plants much worse on the irrigated than on the unirrigated plat.

From the time the water was applied until the tobacco was harvested the effect of the irrigation was visible, though rather less marked than the previous year, when two irrigations were given. As the tobacco was harvested, 48 lath, comprising 288 plants, were weighed from the irrigated and from the unirrigated plat, and the leaves from these plants were weighed after having been cured and stripped. Then in order to ascertain the effect of the irrigation upon the thickness of the leaves, 800 sound leaves were selected from each lot and weighed, after which the length and width of each leaf was measured. The numerical data appear in the following table:

	Weight green.	Weight of cured leaf.	Weight of 800 sound leaves.	Area per lb. of cured leaf.
	Pounds.	Pounds.	Pounds.	Square feet.
288 plants irrigated	744.5	72.95	19.02	42.58
288 plants not irrigated	693.5	68.20	18.48	41.87
Gain presumably from irrigation	51.0	4.75	.54	.71
Per cent. of gain	7.35	6.96	2.92	1.70

As will appear from the data furnished by these trials the irrigation was followed by a perceptible increase in crop, though in the first trial the increased growth appeared to be almost entirely in the stalks. It is of interest also that the irrigation caused a perceptibly thinner leaf, as is shown by comparing the area per pound of cured leaf* of the irrigated and unirrigated plants.

As appears from the figures, the results of one irrigation in 1894 were more satisfactory as regards the yield of cured leaf than of the two irrigations given the preceding year.

*The area of a leaf was computed by multiplying its length by one-half its width, and increasing the product by one-third, it having been ascertained by trial that this is nearly exact. The average length and the average width of a leaf was ascertained by taking measurements of 800 whole leaves.

It is possible that better results might have been secured both seasons had the water been added less rapidly, and the ground been less thoroughly soaked.

No difference was perceptible in the quality of the cured leaf in 1893. In 1894 the irrigated leaf was thought to show fewer of the purple spots so commonly found on tobacco in dry seasons, but this difference was very slight.

From the experiments thus far made, it would appear that less profit is likely to accrue from the irrigation of tobacco than of strawberries.

THE RELATION OF DISTANCE IN PLANTING TO YIELD AND THICKNESS OF LEAF.

In order to ascertain the relation of the distance apart at which the plants grow in the field to the yield and thickness of the cured leaf, 10 rows, 31 inches apart, were set with plants 20 inches apart; 10 rows, 3 feet apart, with plants 20 inches apart, and 10 rows, 3 1-2 feet apart, with plants 2 feet apart. The plants were set June 1st and 2d, topped July 17 and 18, and harvested August 18 and 20. They were taken down about November 3 and stripped during the succeeding week. The following data were noted:

	Yield of 10 rows.	Yield per acre.	Weight of 400 average leaves.	Area per pound of leaf.
	lbs.		lbs.	sq. ft.
3 ft. 6 in. x 2 ft	360.55	1,649.74	9.89	40.86
3 ft. x 1 ft. 8 in	353.4	1,886.53	8.79	42.11
2 ft. 7 in. x 1 ft. 8 in	336.2	2,084.18	9.46	42.01

The results of this experiment as indicated by the above data are of interest, since they seem to show:

1st. The closer planting was followed by a marked increase in yield.

2d. Closer planting in the row was followed by a thinner leaf, but lessening the distance between the rows was not.

It will be observed that in the second and third distances of planting given in the table, the plants were given the same

distance in the row, and they gave nearly the same area of cured leaf per pound, notwithstanding the fact that in the third distance, the rows were placed 5 inches nearer together than in the second distance.

The lesson suggested is that under the conditions a distance of 2 feet and 7 inches between the rows was sufficient for the full development of the plants, because if the crowding had been increased by shortening the distance between the rows it is fair to assume that, with the large yield secured, the leaf would have been rendered thinner.

EXCHANGES.

The Station takes pride in the fact that it has on file an almost complete list of the leading agricultural papers in the United States, besides many from foreign countries, and some not strictly treating of agriculture. These papers come to the Station in exchange for its reports and bulletins. While of the highest value to those connected with the Station as the expression of agricultural experience and sentiment, they are placed where they can be read and referred to by the agricultural students and others of the University, as well as by visitors. Any one desiring sample copies of these papers can as a rule secure them upon application to the publishers, at the addresses given.

FOREIGN EXCHANGES.

Agricultural Gazette, London, England.
Analyst, London, England.
Australian Ironmonger, Melbourne, S. Australia.
Bell's Weekly Messenger, London, England.
Bulletin Des Seances de la Societe Nationale D'Agriculture de France, Paris, France.
Canadian Live Stock and Farm Journal, Toronto, Canada.
Chronique Agricole du Canton du Vaud, Lausanne, Switzerland.
L'Echo Agricole, Courtrai, Belgium.
Dairy, London, England.
Dairy Review, Woodbridge, Suffolk, England.
Extrait des Travaux de la Soc. Centr. d'Agr. de la Seine Inf., Rouen France.
Farmers' Advocate, London, Ontario.
Field, London, England.
Fühling's Landwirthschaftliche Zeitung, Leipsic, Germany.
Illustrated Journal of Agriculture, Montreal, Canada.
Journal für Landwirtschaft, Berlin, Germany.
Journal d'Agriculture Illustre, Montreal, Canada.

Journal of the British Dairy Farmers' Ass'n, London, Eng.
Journal of Royal Agricultural Society of England, London, Eng.
Kgl. Landtbruks Akademiens Handlingar och Tidskrift, Stockholm, Sweden.
Landmandsvennen, Bergen, Norway.
Landwirtschaftliche Wochenblatt f. Schlesw. Holstein, Kiel, Germany.
Le Messager Agricole, Paris, France.
L'Industrie Laitiere, Paris, France.
Live Stock Journal, London, England.
Milch-Zeitung, Bremen, Germany.
Neue Zeitschrift für Rübenzucker-Industrie, Berlin, Germany.
North British Agriculturist, Edinburgh, Scotland.
Nor'West Farmer, Winnipeg, Manitoba.
Revue Internationale des Falsifications, Amsterdam, Holland.
Rural Canadian, Toronto, Canada.
Schweizerische Molkerei Zeitung, Zürich, Switzerland.
Tidsskrift for det norske Landbrug, Christiania, Norway.
Tidsskrift for Landoekonomi, Copenhagen, Denmark.
Ugeskrift for Landmaend, Copenhagen, Denmark.
Ulster Agriculturist, Belfast, Ireland.
Weekly Times, Melbourne, Australia.
Zeitschrift für Nahrungsmittel-Untersuchung und Hygiene, Vienna, Austria.
Zeitschrift des Landw. Vereins in Bayern, Munich, Germany.

DOMESTIC EXCHANGES.

Acker und Gartenbau Zeitung, Milwaukee, Wis.
Agricultural Epitomist, Indianapolis, Ind.
American Agriculturist, New York, N. Y.
American Creamery, Chicago, Ill.
American Cultivator, Boston, Mass.
American Dairyman, New York, N. Y.
American Grange Bulletin, Cincinnati, O.
American Sheep-Breeder and Wool-Grower, Chicago, Ill.
American Swineherd, Chicago, Ill.
Baltimore Weekly Sun, Baltimore, Md.
Boston Weekly Globe, Boston, Mass.
Breeder's Gazette, Chicago, Ill.
Bulletin of the American Devon Cattle Club, Wheeling, W. Va.
Clover Leaf, South Bend, Ind.
Connecticut Farmer, Hartford, Conn.
Country Gentleman, Albany, N. Y.
Creamery and Dairy, Clarksville, Ia.
Creamery Gazette, Ames, Iowa.
Creamery Journal, Waterloo, Iowa.
Cultivator, Omaha, Neb.

Detroit Free Press, Detroit, Mich.
Dorset Quarterly, Washington, Pa.
Der Deutsch-Amerikanische Müller, Chicago, Ill.
Drainage and Farm Journal, Indianapolis, Ind.
Elgin Dairy Report, Elgin, Ill.
Farm and Dairy, Ames, Iowa.
Farm and Fireside, Springfield, Ohio.
Farm and Home, Springfield, Mass.
Farmers' Guide, Huntington, Ind.
Farmers' Home, Dayton, Ohio.
Farmers' Home Journal, Louisville, Ky.
Farmers' Magazine, Springfield, Ill.
Farmers Union, Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farmers' Review, Chicago, Ill.
Farm, Stock and Home, Minneapolis, Minn.
Field and Farm, Denver, Colo.
Geflügel Züchter, Wausau, Wis.
Grange Visitor, Charlotte, Mich.
Hoard's Dairyman, Ft. Atkinson, Wis.
Holstein Friesian Register, Brattleboro, Vt
Home and Farm, Louisville, Ky.
Hospodar, Omaha, Neb.
Indiana Farmer, Indianapolis, Ind.
Industrial American, Lexington, Ky.
Industrialist, Manhattan, Kas.
Iowa Homestead, Des Moines, Ia.
Irrigation Age, Chicago, Ill.
Jersey Bulletin, Indianapolis, Ind.
Kansas Farmer, Topeka, Kas.
Live Stock Indicator, Kansas City, Mo.
Live Stock Report, Chicago, Ill.
Lodi Valley News, Lodi, Wis.
Lousiana Planter, New Orleans, La.
Manitowoc Tribune, Manitowoc, Wis.
Maryland Farmer, Baltimore, Md.
Midland Poultry Journal, Kansas City, Mo.
Mirror and Farmer, Manchester, N. H.
National Stockman, Pittsburg, Pa.
Nebraska Farmer, Lincoln, Neb.
New England Farmer, Boston, Mass.
New England Homestead, Springfield, Mass.
Northwestern Agriculturist, Minneapolis, Minn
Ohio Farmer, Cleveland, Ohio.

Orange Judd Farmer, Chicago, Ill.
Pacific Rural Press, San Francisco, Cal.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago, Ill.
Rural Life, Waterloo, Iowa.
Rural New Yorker, New York, N. Y.
Sheboygan County News, Sheboygan Falls, Wis.
Skördemannen, Minneapolis, Minn.
Southern Cultivator, Atlanta, Ga.
Southern Live Stock Journal, Starkville, Miss.
Southern Planter, Richmond, Va.
St. Croix Republican, New Richmond, Wis.
Sugar Beet, Philadelphia, Pa.
Texas Farm and Ranch, Dallas, Texas.
United States Miller, Chicago, Ill., and Milwaukee, Wis.
Vick's Illustrated Monthly Magazine, Rochester, N. Y.
Western Agriculturist and Live Stock Journal, Chicago, Ill.
Western Rural, Chicago, Ill.
Western Stockman and Cultivator, Omaha, Neb.
Western Swineherd, Genesee, Ill.
Wisconsin Agriculturist, Racine, Wis.
Wisconsin Farmer, Madison, Wis.
Wisconsin Weather and Crop Journal, Milwaukee, Wis.
Wool and Hide Shipper, Chicago, Ill.
Wool and Mutton, Minneapolis, Minn.

ACKNOWLEDGMENTS.

From W. Aldrich & Co., New York City, a copy of Aldrich, Farming Corporations.

Cultures of bacteria, from Prof. Georgeson, Manhattan, Kan.; Chr. Hansen's Lab., Little Falls, N. Y.; Prof. F. G. Novy, Ann Arbor, Mich.; Prof. W. T. Sedgwick, Boston, Mass.; Prof. E. A. de Schweinitz, Washington, D.C., and Prof. T. H. McBride, Iowa City, Iowa.

From Cornish, Curtis & Greene, Ft. Atkinson, Wis., one Pasteurizing machine, one milk cooler.

From J. T. Bentley, Circleville, O., a copy of Bentley's Lightning Calculator.

From Creamery Package Mfg. Co., Chicago, Ill., twenty-five Belknap butter tubs (60 lbs.); four hoop ash tubs; seven spruce butter tubs; six Bradley spruce butter boxes; three Bradley spruce butter pails; four ash butter pails; two white wood crates; six stoneware butter jars.

From J. J. Ryan, Chicago, Ill., one Brown speed indicator.

From E. Sudendorf, Elgin, Ill., one gal. Wells, Richardson's Improved Butter Color.

From L. J. Petit & Co., Milwaukee, Wis., two barrels Diamond Crystal butter salt.

From D. T. Sharples, Elgin, Ill., three blue-print diagrams of separators; one milk measuring pipette.

Babcock milk testers presented during the fall of 1894, by A. H. Barber, Chicago, Ill., 1–12 bottle steam turbine; A. J. Cushman Co., Waterloo, Ia., 1–12 bottle steam turbine; Cornish, Curtis & Greene, Ft. Atkinson, Wis., 1–20 bottle steam turbine; 1–12 bottle hand machine.

From Nixon Nozzle & Machine Co., Dayton, Ohio, plunger for "Progress" force pump.

From S. D. Willard, Geneva, N. Y., buds of horse plum.

From J. G. Jack, Arnold Arboretum, Jamaica Plain, Mass., buds of Chinese peach.

From Joseph Zettel, Sturgeon Bay, Wis., cions of 4 varieties of apples.

From Detroit Paper Package Co., Detroit, Mich., samples of folding paper berry box.

From G. W. Barney, Hartford, Wis., one package each of seedling apples and of cions.

From F. H. Chappel, Oregon, Wis., cions of Wisconsin Baldwin apple.

HERD BOOKS.

Davy's Devon Herd Book, Vol. XVII,
John Risden, Jr., Wivelscombe, Somerset, England.
The National Pig Breeders' Asscn. Herd Book, Vol. X,
John Parr, Secy., 44 Mapperly Road, Nottingham, England.
Victoria Swine Record, Vols. I and II,
Geo. F. Davis, Secy., Dyer, Ind.
American Shropshire Sheep Record, Vol. IX,
Mortimer Levering, Secy., La Fayette, Ind.
Suffolk Sheep Society Flock Book, Vol. VIII,
Ernest Prentice, Secy., Stowmarket, England.
Standard Poland China Record, Vol. VII,
Geo. F. Woodworth, Secy., Maryville, Mo.
American Oxford Down Record, Vol. V,
W. A. Shafor, Secy., Middleton, Ohio.
Wensleydale Flock Book, Vol V,
T. J. Other, Secy., Howgrave, Ripon, England.
The Oxford Down Flock Book, Vol. VI,
R. Henry Rew, Secy., London, England.
Clydesdale Stud Book of Canada, Vol. VII,
Henry Wade, Secy., Toronto, Canada.
Holstein-Friesian Herd Book, Vols. VIII, IX, X, XI,
Thos. B. Wales, Secy., Boston, Mass.
Improved Essex Swine Record, Vol. II,
F. M. Srout, Secy., McLean, Ill.
Gestütbuch der holsteinischen Marschen, Vol. III,
C. Von Drathen, Greeley, Iowa.
Herd Book de la Race Normande Pure, Bulletins 1–9, inclusive,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book Francais, Race Durham, Vols. XVI–XIX, inclusive,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book de la Race Nivernaise-Charolaise, Vols. 1–2, 2nd Series,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book de la Race Charolaise, Bulletin I and Statutes,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book de la Race Limousine Pure, Bulletins 1–4, inclusive,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book de la Race Tarentaise, Bulletins 1–4, inclusive,
E. Tisserand, Minister of Agrl., Paris, France.
Herd Book de la Race Bretonne Pie-Noire, Bulletins 1–4, inclusive
E. Tisserand, Minister of Agrl., Paris, France.
The Cotswold Flock Book, Vols. 1–3,
Jas. W. Taylor, Secy., Cold Aston, Cheltenham.

North Wales Black Cattle Herd Book, Vols. I–IV,
W. Arthur Dew, Secy., Wellfield, Bangor, England.
English Guernsey Herd Book, Vols. IX and X,
Julian Stephens, Secy., London, England.
Herd Book Dutch Belted Cattle Assn., Vol. IV,
H. B. Richards, Secy., Easton, Pa.
American Guernsey Herd Register, Vol. V,
Wm. H. Caldwell, Secy., Peterboro, N. H.
Standard Poland-China Record, Vol. VIII,
Ira K. Alderman, Secy., Maryville, Mo.
Herd Book Maine State Jersey Cattle Asscn.. Vols. I, IV, VI,
N. R. Pike, Sec'y., Winthrop, Maine.
Clydesdale Stud Book, Vol. XV, XVI,
Archibald M'Neilage, Sec'y., Glasgow, Scotland.
Holstein-Friesian Herd Book, Vol. XII,
F. L. Houghton, Sec'y., Brattleboro, Vt.
American Southdown Record, Vol. IV,
Jno. G. Springer, Sec'y., Springfield, Ill.
Reg. of Vermont Merino Sheep Breeders' Asscn , Vol. IV,
Albert Chapman, Sec'y., Middleburg, Vt.
Ohio Poland China Record, Vol. XVI,
Carl Friegan, Sec'y., Dayton, Ohio.
British Berkshire Herd Book, Vol. X,
Heber Humphrey, Sec'y., Shippon, Abingdon, England.
Jersey Herd Book, Vol. XII,
Joshua Le Gros Sec'y., St. Helier, Jersey Isle, England

FINANCIAL STATEMENT.

The Wisconsin Agricultural Experiment Station, in Account with the United States Appropriation.

1894.	Page.	Cr.	Dr.
To receipts from Treasurer of the United States, as per appropriation for the year ending June 30th, 1894, under act of Congress, approved March 2d, 1887	14	....	$15,000 00
By salaries	25	$6,800 00	....
By labor	35	3,727 96	....
By laboratory supplies	45	160 60	....
By farm supplies	55	187 03	....
By freight and express	65	126 45	....
By postage and office supplies	75	123 97	....
By library	85	....	....
By farm implements	95	965 85	
By apparatus	105	280 62	....
By furniture	115	....	....
By fencing and drainage	125	256 06	....
By seeds and plants	135	78 96	....
By live stock	145	159 83	....
By feed	155	791 09	....
By traveling	165	113 55	....
By fuel and light	175	731 27	....
By incidental expenses	185	41 50	....
By building and repairs	195	455 26	....
		$15,000 00	$15,000 00

I hereby certify that the foregoing statement is a true copy from the books of account of the institution named.

(Signed) E. F. RILEY,
Secretary Board of Regents,
University of Wisconsin.

MADISON, Wisconsin, July 12, 1894.

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